



Pedestrian Safety Countermeasures Along Delaware's SR 1 Beach Corridor

Roadway Management Conference 2021



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Presentation Outline

- Delaware's Strategic Highway Safety Plan – Pedestrian Emphasis Area
- Statewide Pedestrian Crash Statistics
- Statewide Pedestrian Safety Initiatives
- Pedestrian Safety Countermeasures in Action
 - Focus on RRFBs
 - Dewey Beach Area Pedestrian Safety Improvements
 - Bethany Area Pedestrian Safety Improvements
 - Before and After RRFB Data
 - RRFB Evaluation and Design Considerations
 - Focus on Pedestrian Hybrid Beacons (HAWKs)
 - Lewes/Rehoboth Beach Area Pedestrian Safety Improvements
 - HAWK Compliance Study Results and Next Steps
- Strategies and Actions for Improving Pedestrian Safety



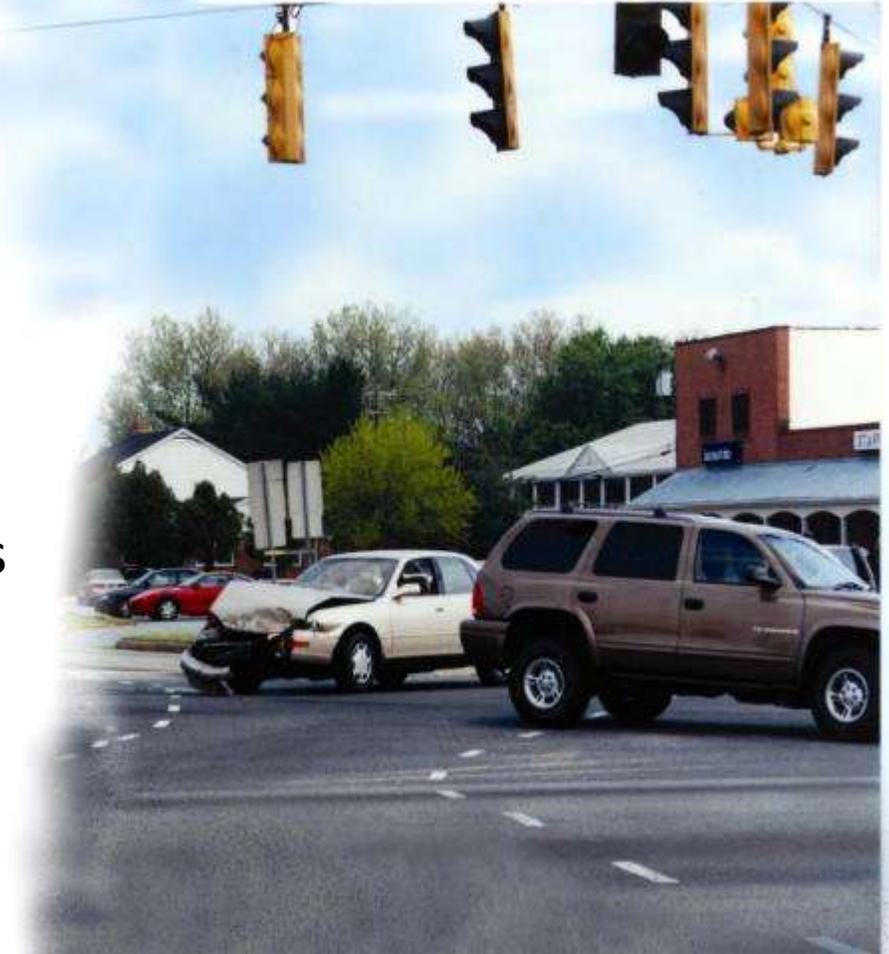
2021-2025

Delaware Strategic Highway Safety Plan



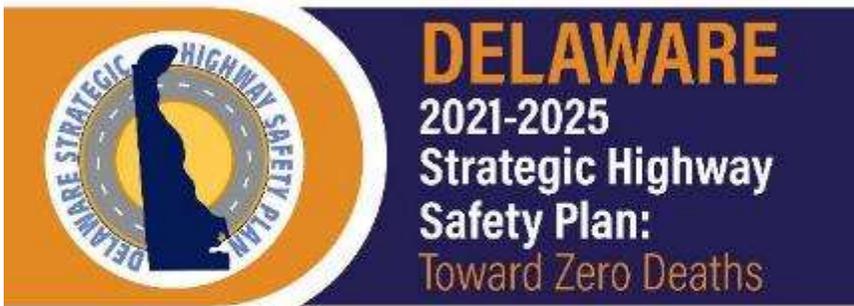
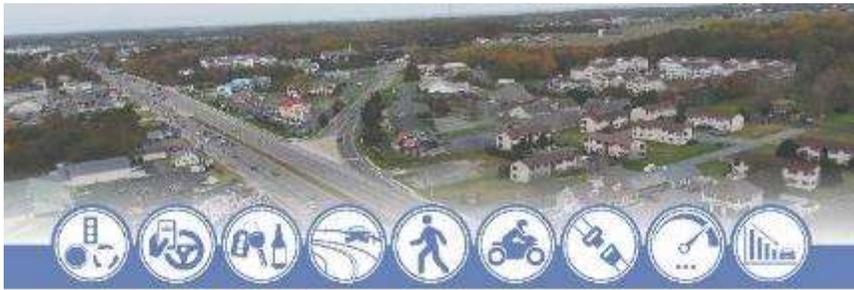
What is an SHSP?

- Comprehensive, multi-year, **data driven** transportation safety plan with a goal of reducing highway fatalities and serious injuries on all public roads
- Establishes consistent statewide goals, objectives, emphasis areas, priorities, and countermeasures with stakeholders and other transportation plans
- Makes effective use of crash data to determines priorities
- Addresses **4 E's of Highway Safety**
 - Engineering
 - Education
 - Enforcement
 - Emergency Medical Services





Delaware Strategic Highway Safety Plan



GOAL

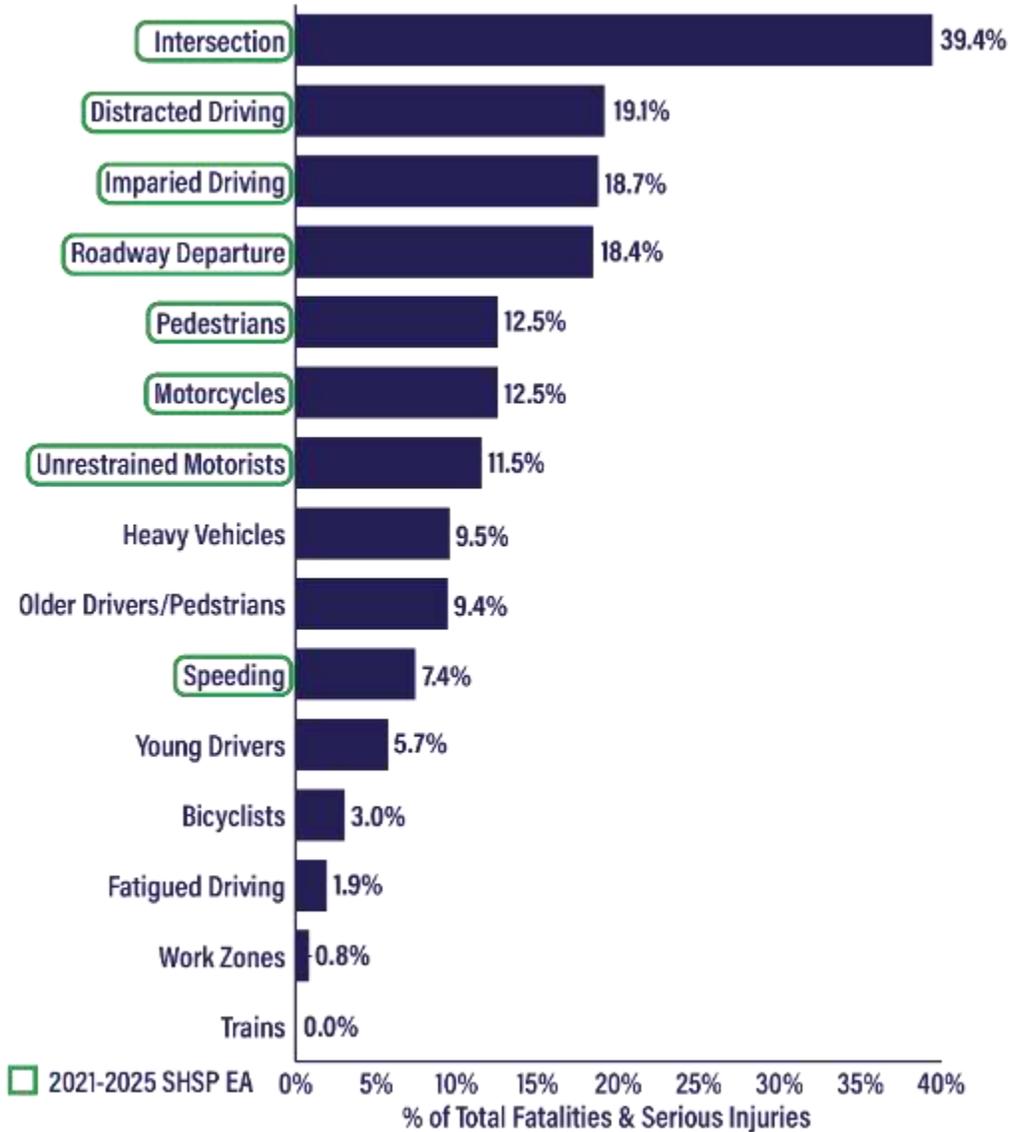
The Delaware Strategic Highway Safety Plan: **Towards Zero Deaths** aims to eliminate fatalities and serious injuries on Delaware's roadways through a multi-agency approach that utilizes education, enforcement, engineering and emergency medical service strategies.

OVERALL OBJECTIVE

Delaware's 2021-2025 SHSP objective is to **reduce fatalities and serious injuries by 15% over the next five years** to ultimately reach the goal of zero fatalities and serious injuries on Delaware's roadways.



2021-2025 SHSP Emphasis Areas



REDUCE
Pedestrian
Fatalities & Serious Injuries by
15%
from **76 to 64,**
over the next **5 years.**

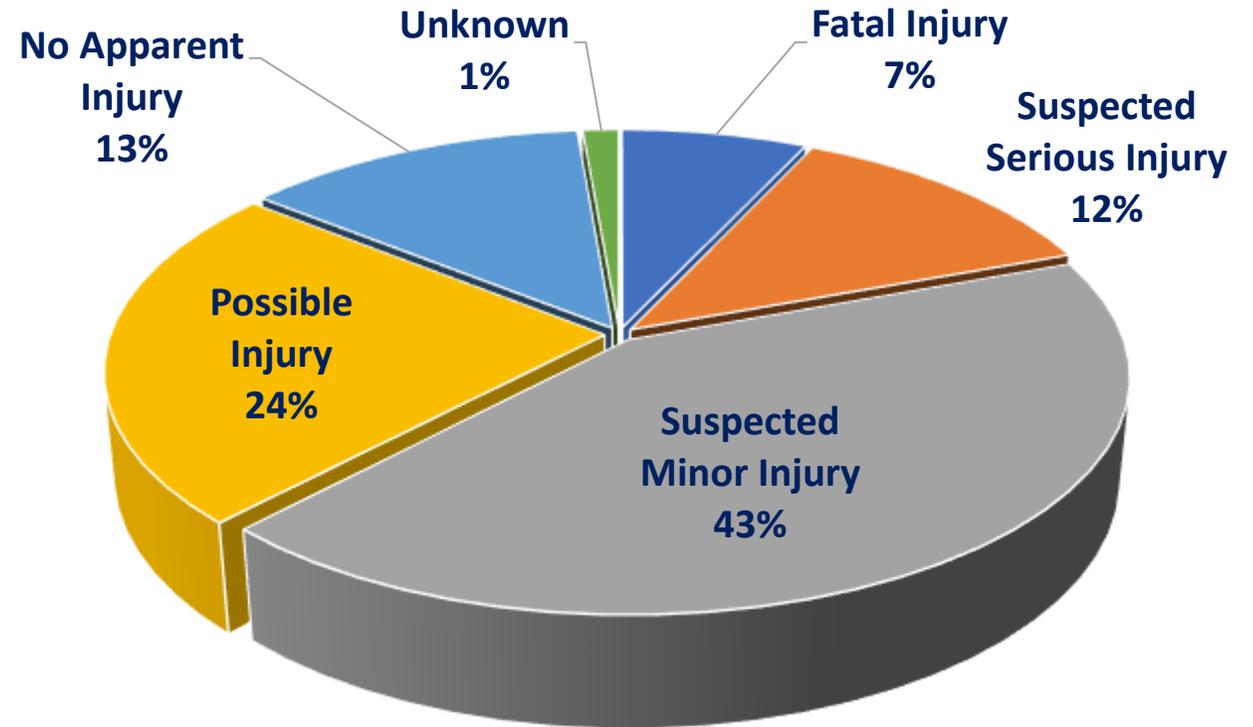


Statewide Pedestrian Crash Statistics



Statewide Pedestrian Crash Statistics

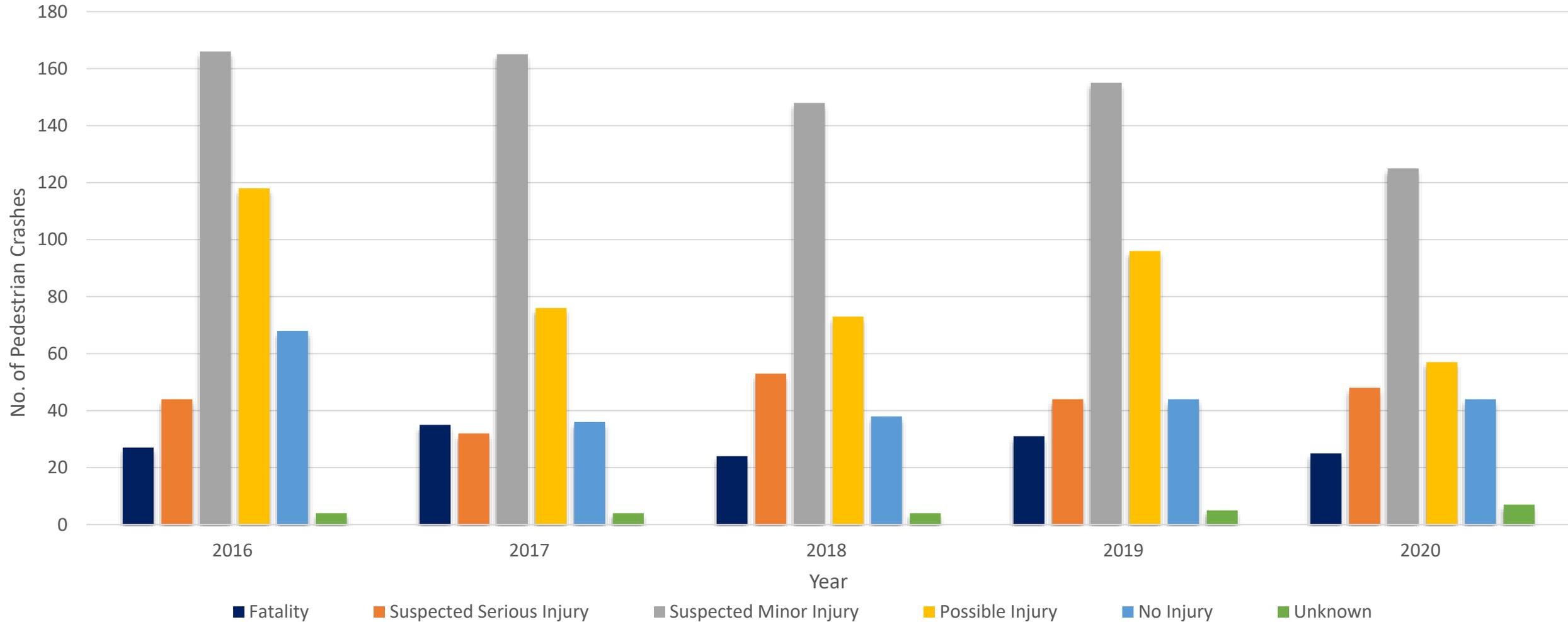
- Jan. 16, 2016 – Dec. 31, 2020
- Source: DelDOT's CARS Program
- All crash severities
 - Property Damage Only
 - Injury
 - Fatal
- Overall crash statistics
 - 1,721 pedestrian crashes
 - 1,796 pedestrians involved
 - 142 pedestrians killed
 - 221 pedestrians seriously injured
 - 759 pedestrians with minor injuries
 - 420 pedestrians with possible injuries





Statewide Pedestrian Crash Statistics

Statewide, pedestrian crashes accounted for 1.3% of all crashes and 24% of all fatalities from 2016 through 2020





DE Pedestrian Fatalities vs. Region

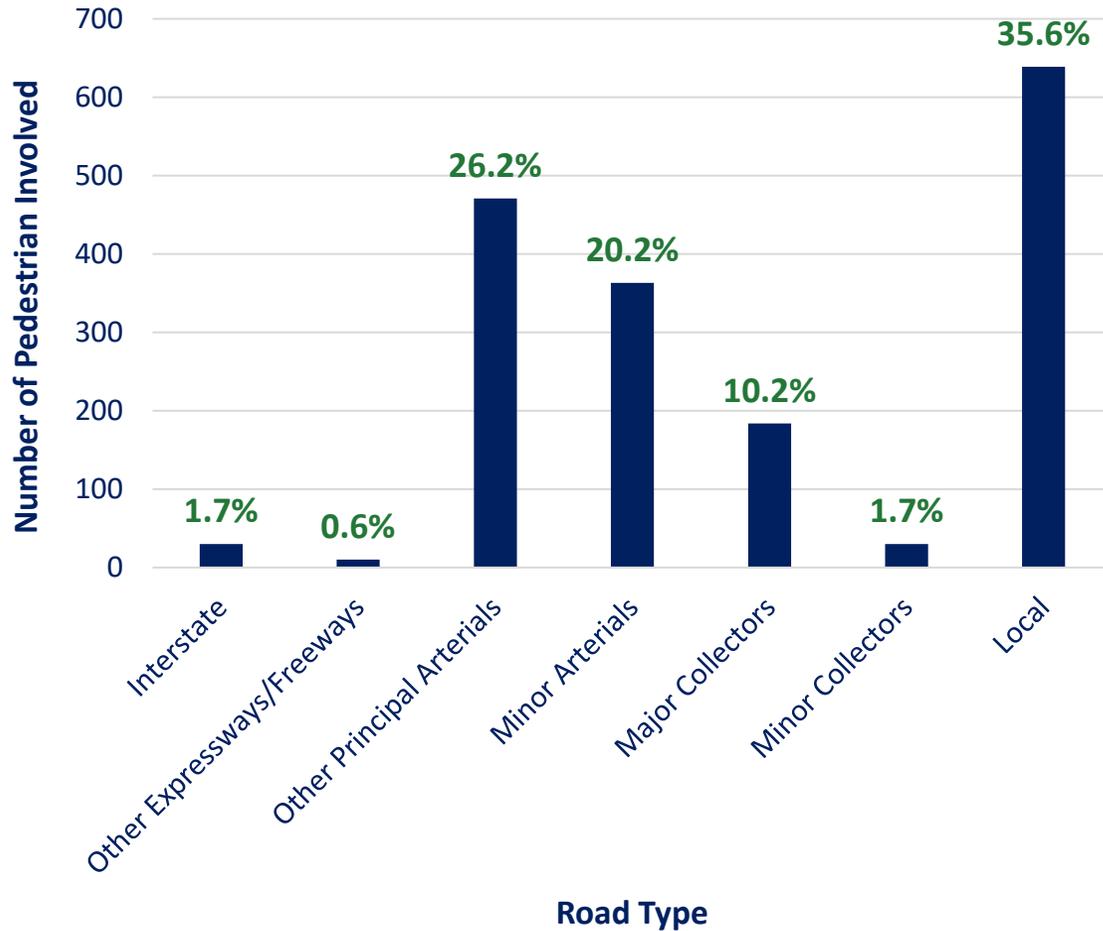
Pedestrian fatalities per 100k population	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Delaware	1.85	2.41	1.69	2.45	1.98	2.94	2.70	2.67	3.70	2.84	3.43	2.38	3.29
D.C.	3.23	1.52	2.33	2.15	1.29	1.11	1.39	1.37	1.93	1.17	1.59	1.57	1.28
Maryland	2.06	2.06	1.98	1.75	1.75	1.63	1.82	1.69	1.53	1.73	1.88	2.12	2.03
Pennsylvania	1.21	1.10	1.06	1.14	1.15	1.28	1.15	1.26	1.18	1.32	1.15	1.54	1.15
Virginia	1.14	0.98	0.93	0.91	0.90	1.20	0.91	1.06	0.92	1.45	1.31	1.39	1.44
West Virginia	1.49	0.72	1.15	0.70	1.08	1.67	1.51	1.03	1.03	1.31	1.43	1.22	1.73
Max. State Rate/Yr	3.23 (DC)	2.67 (FL)	2.51 (FL)	2.45 (DE)	2.57 (FL)	2.94 (DE)	2.70 (DE)	3.55 (NM)	3.70 (DE)	3.51 (NM)	3.54 (NM)	3.96 (NM)	3.96 (NM)
Min. State Rate/Yr.	0.38 (WY)	0.28 (NE)	0.37 (WY)	0.44 (NE)	0.38 (NE)	0.24 (SD)	0.14 (ND)	0.48 (NE)	1.48 (ID)	0.63 (NE)	0.66 (ND)	0.52 (ME)	0.48 (VT)

States in NHTSA's Region 3

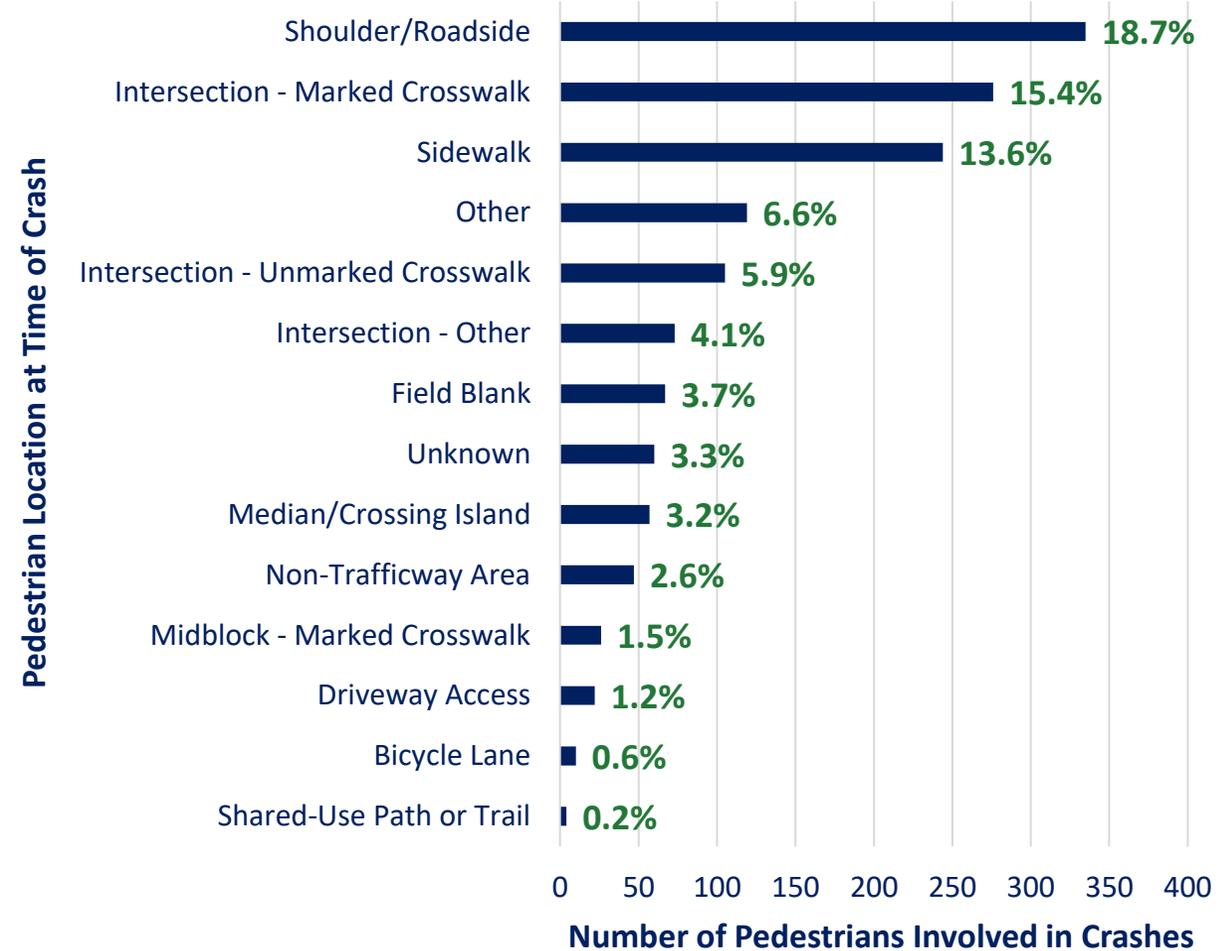


Statewide Pedestrian Crash Statistics – Where?

45% of pedestrian fatalities occurred on Principal Arterials



85% of pedestrian fatalities were non-intersection related



% of Total Pedestrians Involved in Crashes



Statewide Pedestrian Crash Statistics – When?

	12A	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A	11A	12P	1P	2P	3P	4P	5P	6P	7P	8P	9P	10P	11P	Totals
Sunday	3	14	3	2			1			2	4	2	3	4	3	1	5	11	16	11	10	9	4		108
Monday	4	1		1	3	1	2	3	16	3	3	8	5	4	13	8	10	19	13	11	12	12	7	3	162
Tuesday	7	7	5	1		5	10	15	22	18	21	28	24	23	32	39	44	56	43	45	43	32	30	16	566
Wednesday	3		3	3	2		4	8	14	9	6	7	11	10	8	13	16	15	21	12	14	17	6	5	207
Thursday	7	5	7	3	4	6	16	10	16	10	8	17	13	10	17	18	13	27	29	15	24	17	14	13	319
Friday	5	2		1		2	6	7	13	9	4	2	19	14	8	11	11	13	32	20	13	16	11	8	227
Saturday	8	9	5	2	5	5	5	3	3	5	3	7	8	4	8	13	17	5	19	18	19	19	11	6	207
Totals	37	38	23	13	14	19	44	46	84	56	49	71	83	69	89	103	116	146	173	132	135	122	83	51	1796

Lower Frequency Higher Frequency XX Number of Pedestrians Involved in Crashes

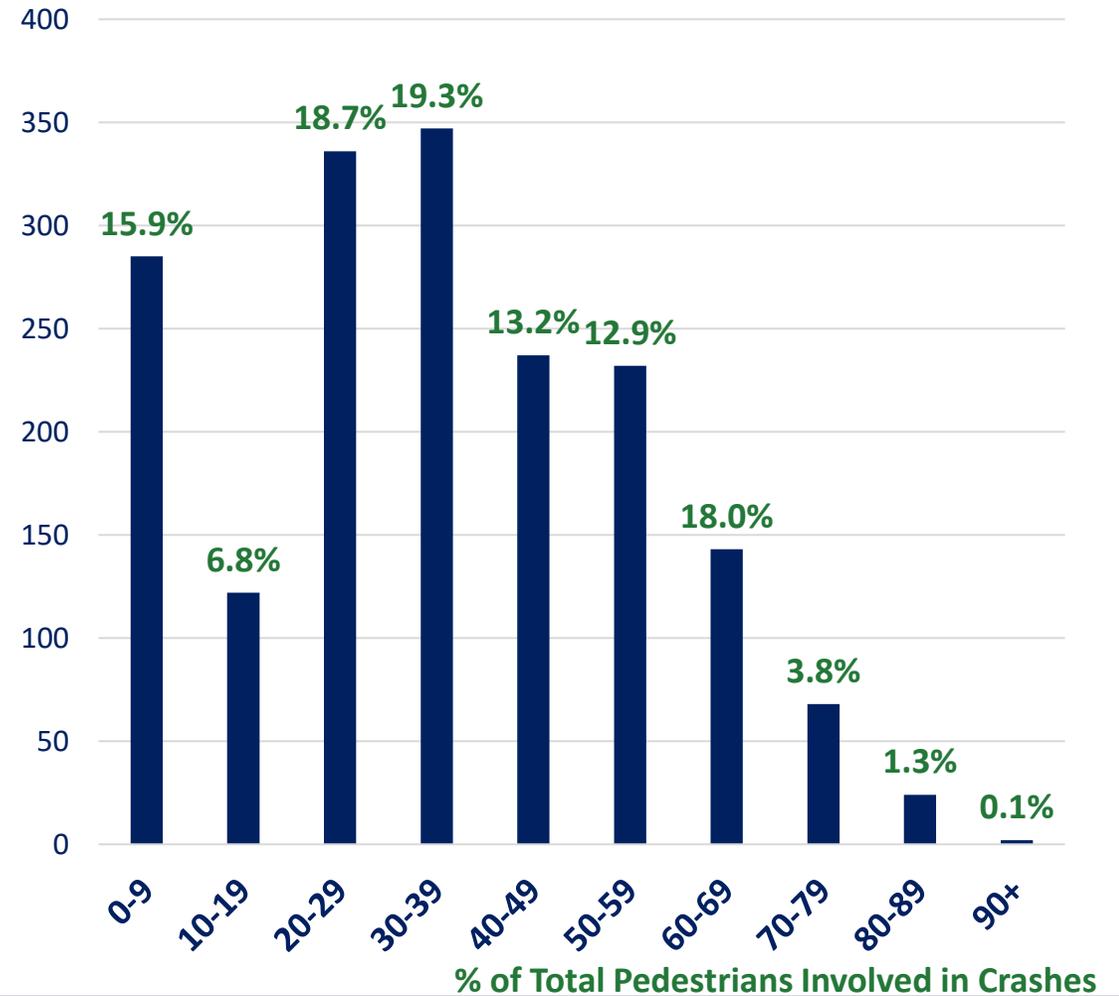
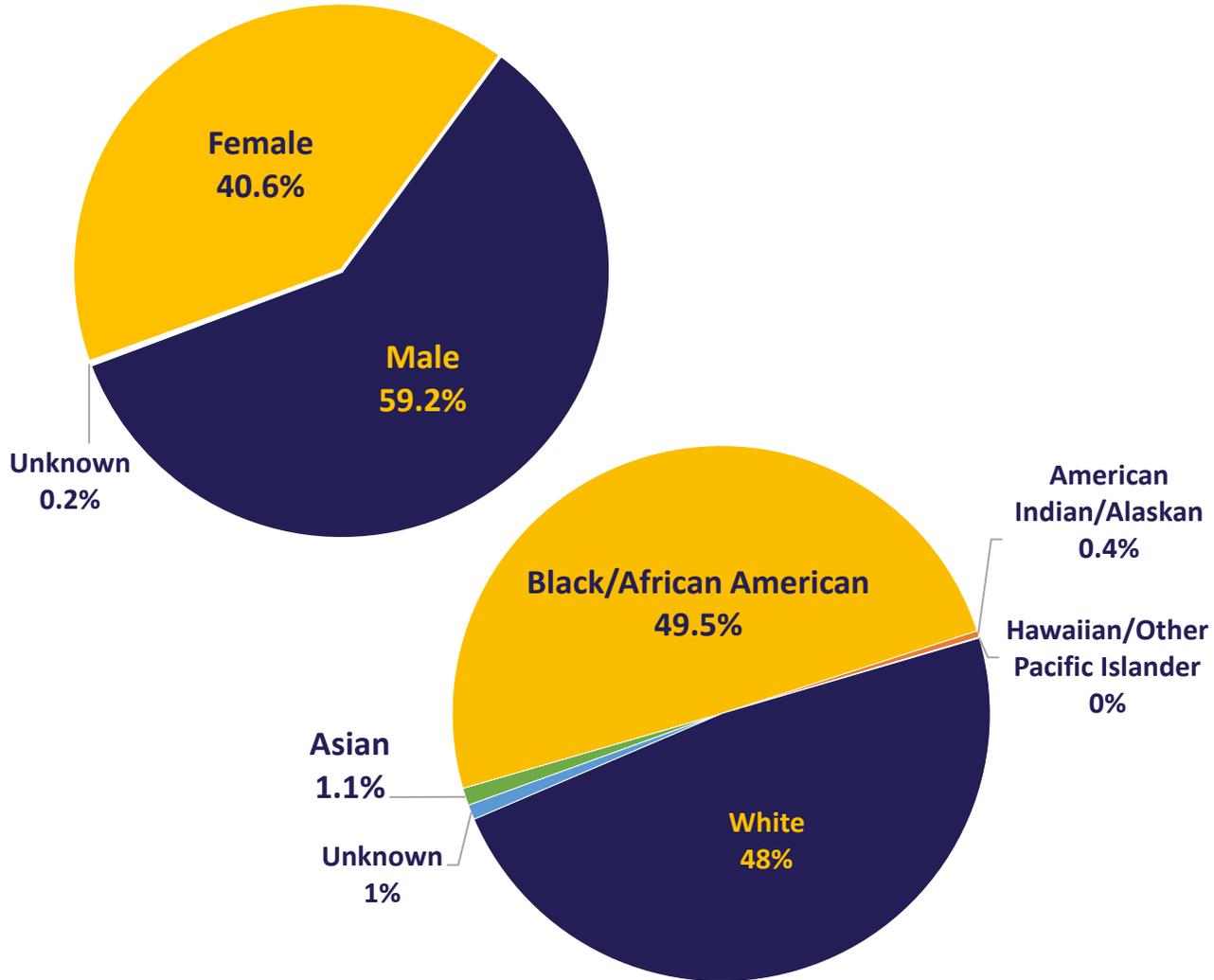


35% of pedestrian fatalities occurred in November, December and January

% of Total Pedestrians Involved in Crashes



Statewide Pedestrian Crash Statistics – Who?



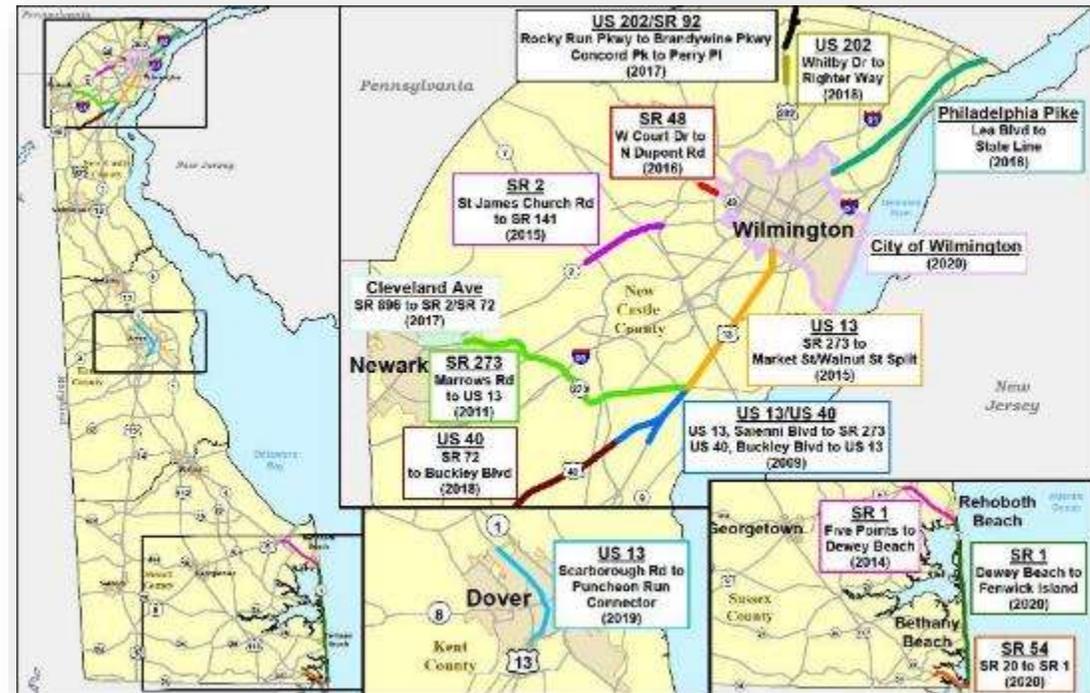


Statewide Pedestrian Safety Initiatives



Statewide Pedestrian Safety Initiatives

- Pedestrian Safety Audits
 - Better understand specific pedestrian crash trends
 - Multidisciplinary audit team to review corridors and make recommendations
 - Improvements are implemented as part of existing or future projects and programs
 - Since 2015, DeDOT has completed 10 audits/assessments and implemented various improvements
 - US 13 from Llangollen Boulevard to A Street
 - SR 273 from US 13 to SR 72
 - Kirkwood Highway from St. James Church Road to SR 141
 - US 13 Dover from Scarborough Road to Puncheon Run Connector
 - SR 1 from Lewes to Dewey Beach
 - US 202
 - SR 48 from SR 141 to DuPont Road





Statewide Pedestrian Safety Initiatives

Typical Pedestrian Safety Countermeasures:

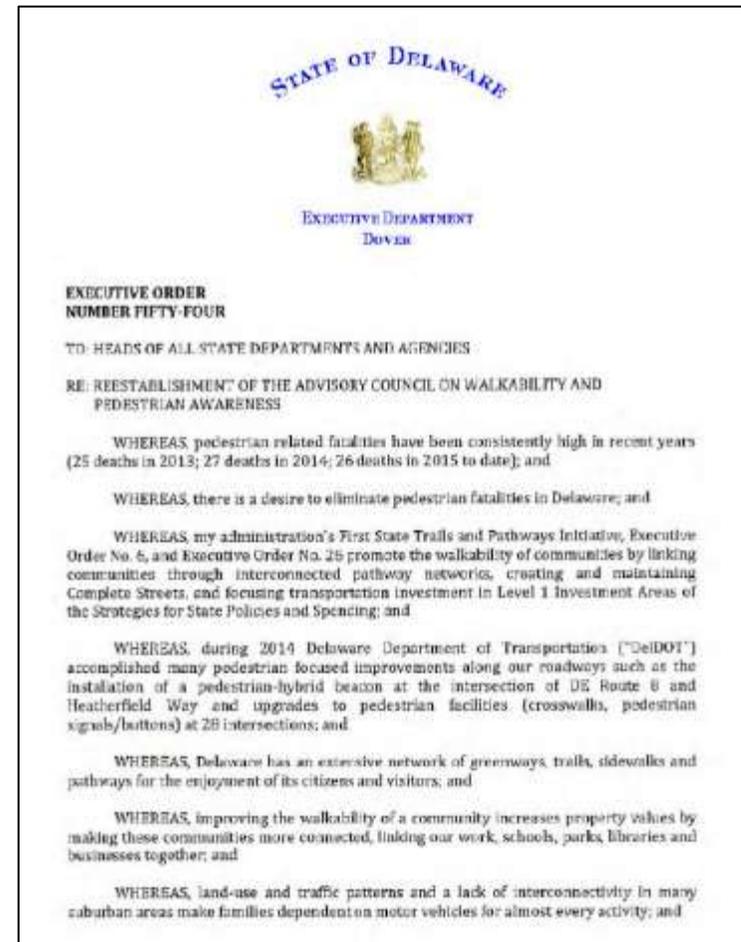
- Painted crosswalks at signalized intersections
- Pedestrian signalization
- Marked crosswalks at appropriate mid-block crossing locations
- Active/enhanced pedestrian crossing systems (i.e., RRFBs)
- Corner sight distance improvements
- Curb bump outs to decrease crossing distances
- Median refuge areas
- Audible pedestrian signals
- Transit improvements
- Sidewalk connectivity improvements
- Traffic calming
- Improved warning signage
- Barriers to prevent undesired mid-block crossings





Statewide Pedestrian Safety Initiatives

- Advisory Council on Walkability and Pedestrian Awareness (Pedestrian Council)
 - Established October 12, 2015, by Governor Markell
 - Appointed membership included state agencies, planning councils, advocacy groups and the public
 - Areas of focus
 - Identifying gaps in the system of pedestrian paths and sidewalks
 - Provide advice regarding design standards for crosswalks, sidewalks, and pathways ensuring ADA compliance
 - Provide advice regarding implementation of DeIDOT's Sidewalk and Multi-Use Path Maintenance Policy
 - Review traffic rules to help support a safe pedestrian environment
 - Provide advice regarding accessibility and connectivity in an effort to make transit a more viable option
 - Developing strategies for pedestrian safety education and awareness
- Subcommittees
 - Built Environment
 - Legislative
 - Education and Enforcement

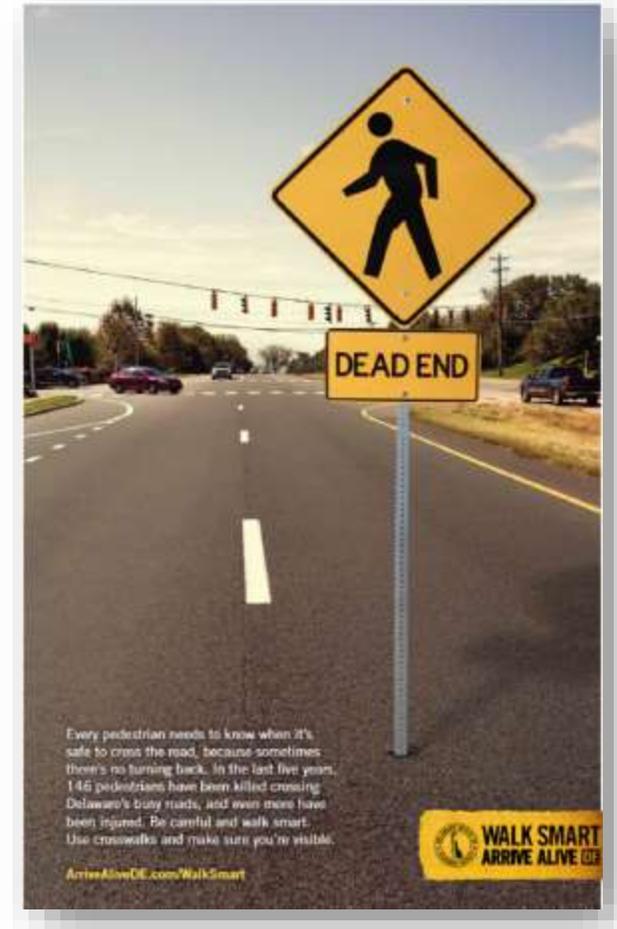


Pedestrian Council website: https://deldot.gov/Programs/pedestrian_council/index.shtml



Statewide Pedestrian Safety Initiatives

- Pedestrian Education Countermeasures
 - Managed by Delaware Office of Highway Safety
 - Continued education outreach campaigns
 - Targeted media outreach
 - Community outreach
 - Alliance Sports Marketing
 - Cross Country Races
 - Elementary school programs
 - Corporate/Public Partner Program
 - OHS Safety Conference
 - Banners for schools
 - Beach events: Partnership with Ocean City Pedestrian Task Force
 - Pedestrian Speed Demo



WALK SMART. ARRIVE ALIVE DE

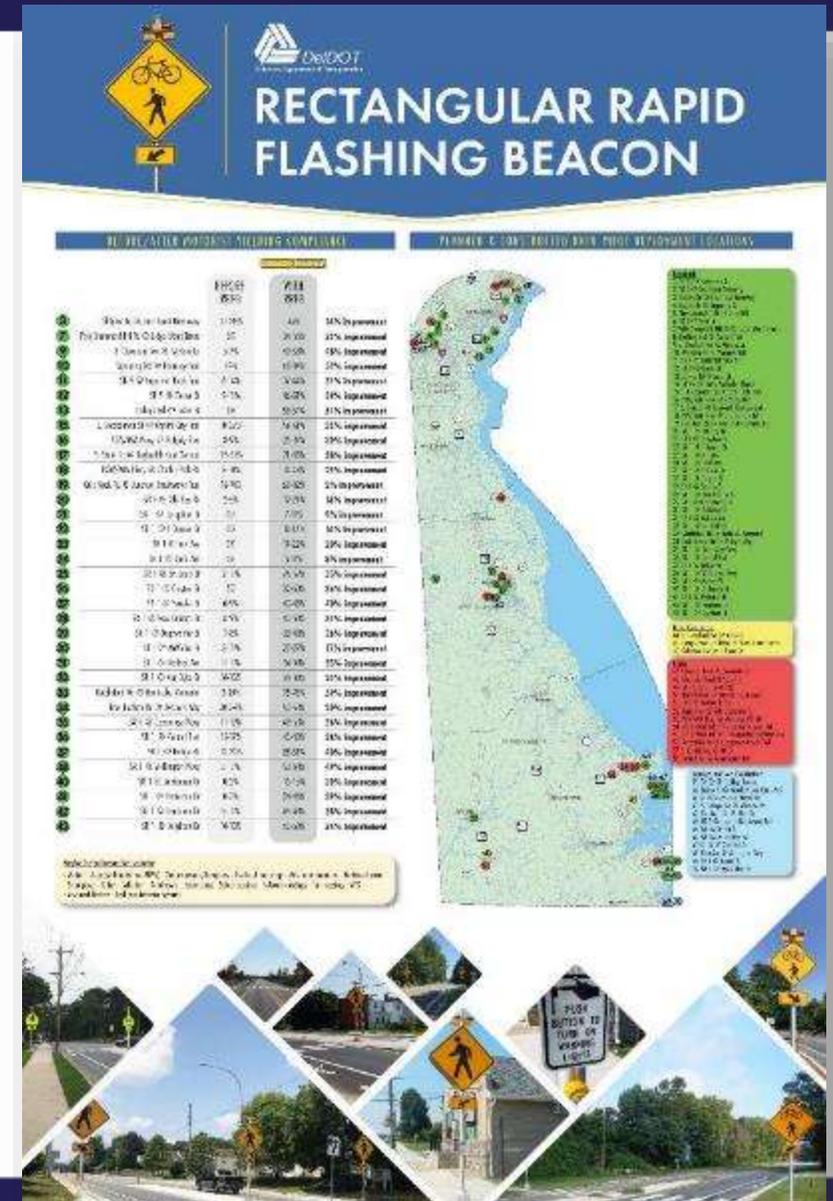


Pedestrian Safety Countermeasures in Action – RRFBs in Dewey Beach and Bethany Area



Pedestrian Safety Countermeasures - RRFBs

- Rectangular Rapid Flashing Beacon
 - Pedestrian-actuated warning device used at uncontrolled, marked crosswalks
 - Intended to improve compliance with motorists yielding to pedestrians in marked crosswalks
 - First installation in April 2016
 - 43 locations completed since 2016
 - 3 currently under construction
 - 12 planned for future construction
 - 25% average improvement in motorist yielding compliance across all sites





Pedestrian Safety Countermeasures - RRFBs

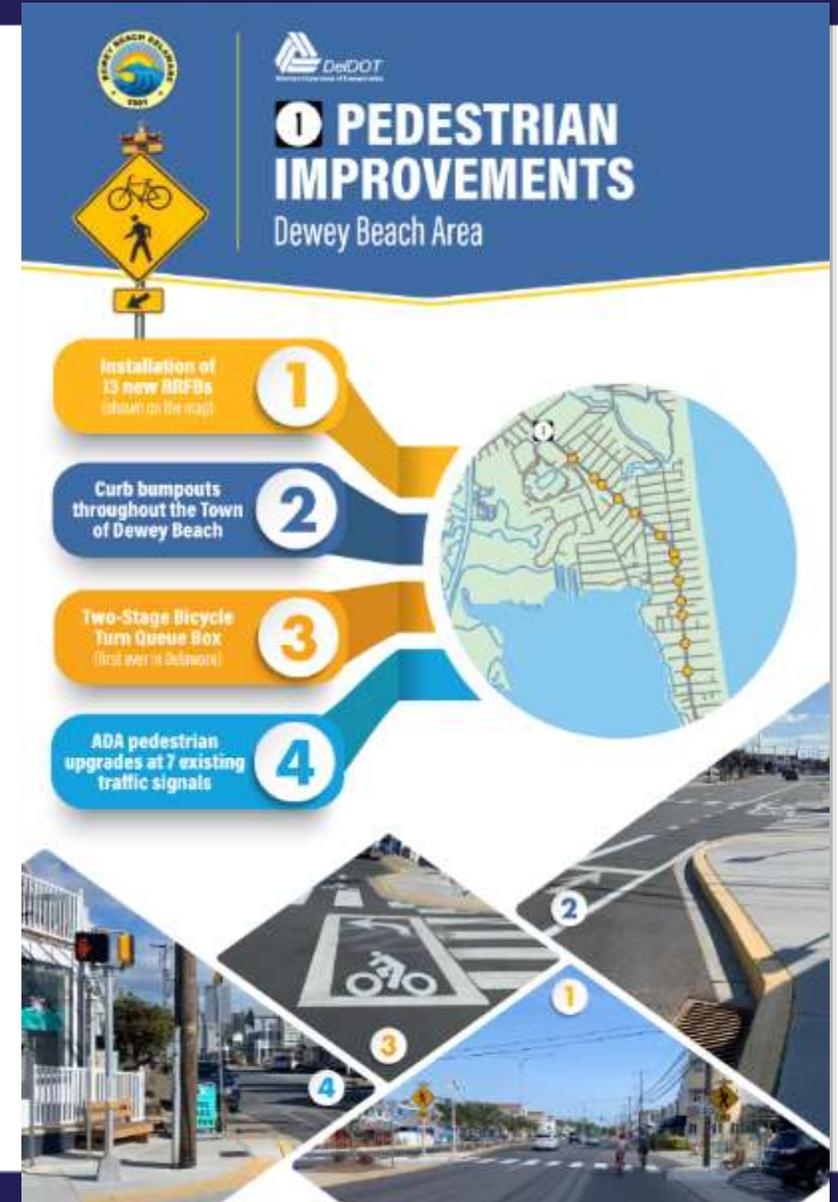
- Rectangular Rapid Flashing Beacons – How do they Operate?





Dewey Beach Area Improvements

- 2018/2019 → Design and Construction of SR 1 Pave and Rehab Project between Rehoboth Canal and Dewey Beach
 - Coordination with legislators and various sections within DelDOT to install RRFBs at 3 existing uncontrolled crosswalks and establish 2 new uncontrolled crosswalks with RRFBs
 - Known locally as “Forgotten Mile” – lined with motels but quieter than heavily commercial/retail areas in Dewey Beach and Rehoboth Beach





Dewey Beach Area Improvements

RRFB Locations – SR 1, Rehoboth Canal to Dewey Beach



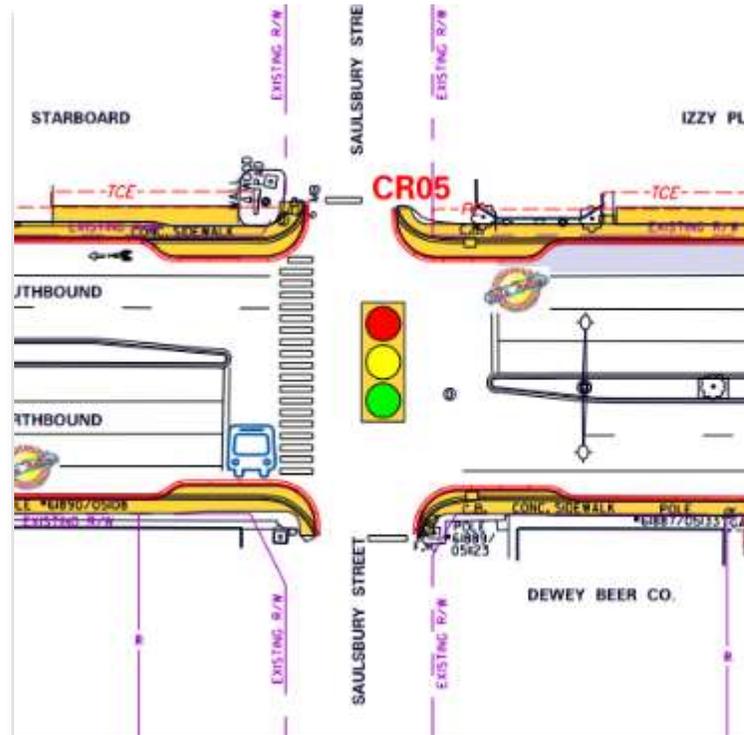
- ★ RRFB at Existing Crosswalk (3)
 - SR 1 @ Dodd Ave
 - SR 1 @ Ann Ave
 - SR 1 @ Old Bay Rd
- ★ RRFB at New Crosswalk (2)
 - SR 1 @ F Benson St
 - SR 1 @ Joesphine St
- 🚦 Existing Signalized Crosswalk (2)
 - SR 1 @ Bayard Ave
 - SR 1 @ Spring Lake Dr



Dewey Beach Area Improvements

2019 → Dewey Beach ADA Assessment

- ADA assessment conducted through DelDOT's PAR program
- Included two conceptual alternatives that were used to establish a capital project:
 - Short-Term Alternative: isolated sidewalk widening, curb line adjustments and utility relocations to eliminate ADA pinch-points
 - Long-Term Alternative: implement short-term solutions above and include curb bumpouts to provide more room for pedestrians at critical crossing locations



SR 1, Dewey Beach
Anchor Way to Bayard Avenue
Pedestrian Access Routes (PAR):
ADA Assessment

April 2019

Delaware Department of Transportation
Agreement No. 1789, Task 1





Dewey Beach Area Improvements

2019/2020 → Dewey Beach Pave and Rehab → TIME TO ACT FAST!!!

- DeIDOT and Town of Dewey = emergency coordination
- GOAL: implement as many long-term solutions as possible within scope of upcoming pave and rehab project to
- QUIT KICKING THE CAN DOWN THE CURB!!
- Obtained FHWA approval to add the Dewey Beach Pave and Rehab location to the existing “Forgotten Mile” contract
 - Eliminated bid/award/pre-construction process
 - Eliminated contractor mobilization costs and streamlined workflow
 - Quasi-design-build process with contractors, engineers, DeIDOT and the Town



Dewey Beach Area Improvements

Curb Bumpouts:

- 31 total at 11 intersections
- Reduces pedestrian crossing distances
- Promotes traffic calming and reduces turning speeds
- Eliminates non-compliant pinch points (i.e., utility pole in narrow sidewalk)
- Provides more area for pedestrians at critical crossing areas/conflict points





Dewey Beach Area Improvements

Curb Bumpouts



B E F O R E



A F T E R



B E F O R E

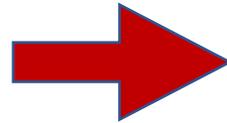


A F T E R



Dewey Beach Area Improvements

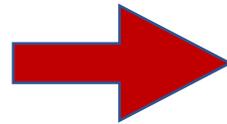
Curb Bumpouts





Dewey Beach Area Improvements

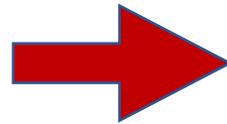
Curb Bumpouts





Dewey Beach Area Improvements

Curb Bumpouts





Dewey Beach Area Improvements

8 new RRFBs in Town Limits





Dewey Beach Area Improvements

RRFB Locations – SR 1, Town of Dewey Beach

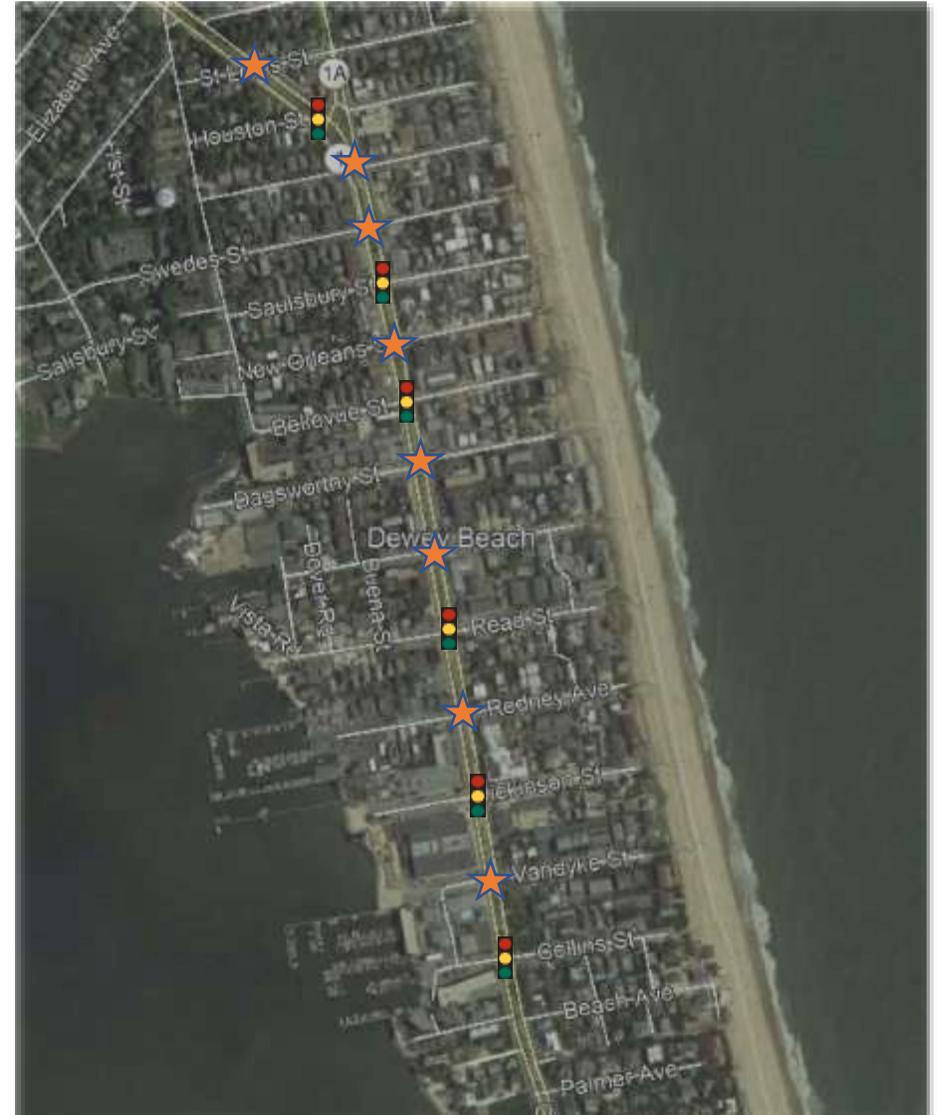


★ RRFB at Existing Crosswalk (8)

- SR 1 @ Van Dyke Ave
- SR 1 @ Rodney Ave
- SR 1 @ McKinley Ave
- SR 1 @ Dagsworthy Ave
- SR 1 @ New Orleans St
- SR 1 @ Swedes St
- SR 1 @ Clayton St
- SR 1 @ St. Louis St



Existing Signalized Crosswalk (6)





Dewey Beach Area Improvements

Pedestrian Upgrades at Traffic Signals:

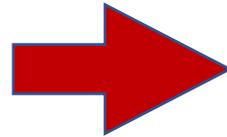
- New painted crosswalks on side streets
- New ADA-compliant pedestrian signals located at level landing areas
- Reconstruction of non-compliant curb ramps
- Removal of outdated/non-compliant infrastructure (i.e., non-countdown pedestrian signal heads)





Dewey Beach Area Improvements

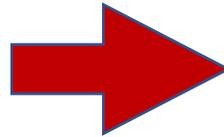
Pedestrian Upgrades at Traffic Signals





Dewey Beach Area Improvements

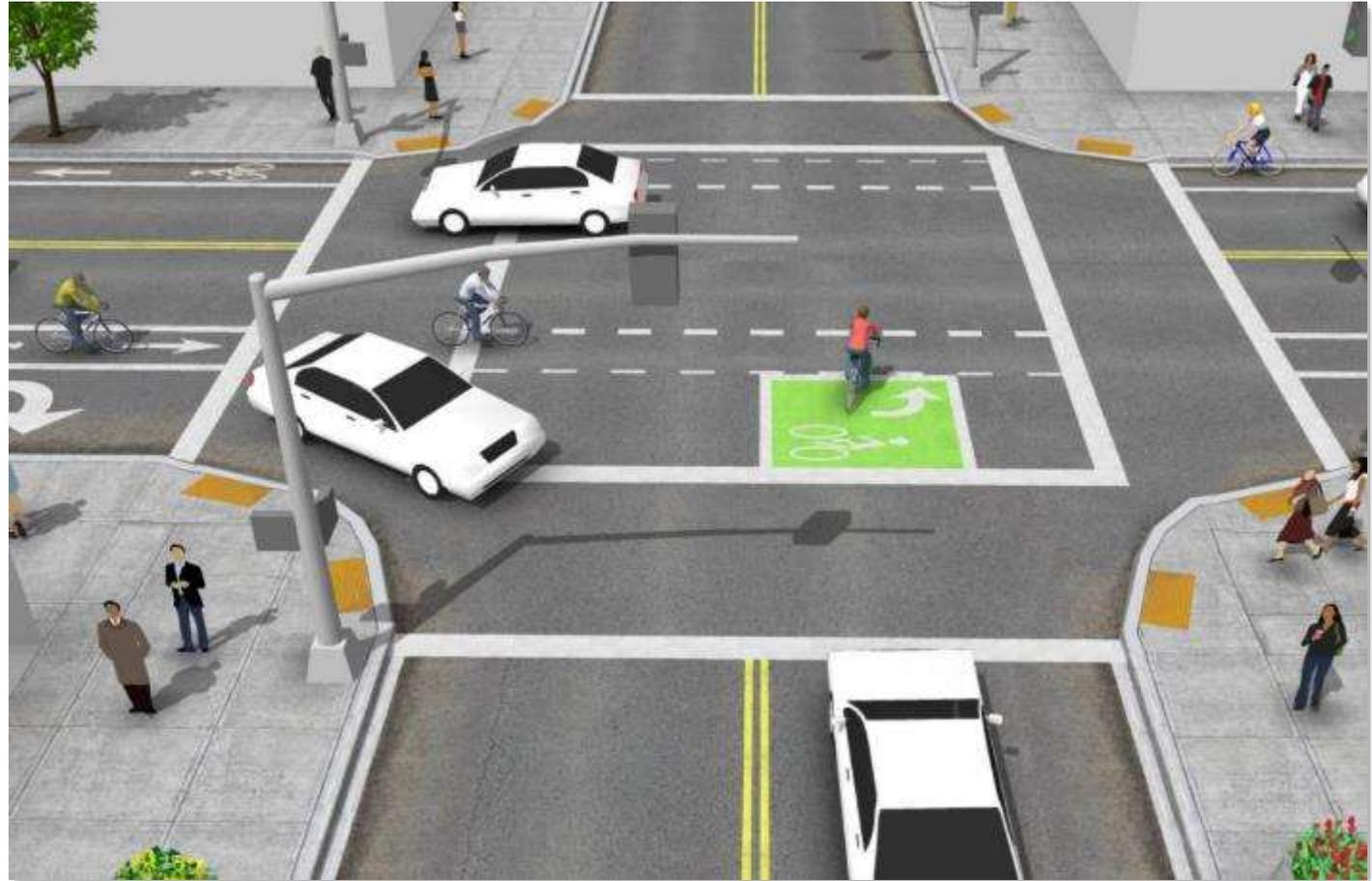
Pedestrian Upgrades at Traffic Signals





Dewey Beach Area Improvements

- Two-stage left-turn bike boxes
 - Delaware's first ever application
 - FHWA interim approval issued 2017
 - Allows cyclists to safely make a left turn from the right shoulder/bike lane without having to merge across through lanes and into a left-turn lane
 - Includes specialized in-pavement loop detectors for passive bicycle detection to call the side street phase





Dewey Beach Area Improvements



Left Turn Bike Box Design & Implementation Considerations:

- Agency must request and receive written approval from FHWA for use
- 3'x10' recommended minimum size
- Right turns on red shall be prohibited for side street traffic
- Shall contain passive bicycle detection if vehicular approach is actuated
- Green colored pavement and guide signing is optional (regulatory signing required if use is mandatory)
- Position to avoid conflicts with adjacent crosswalks and bicycle lane



Dewey Beach Area Improvements



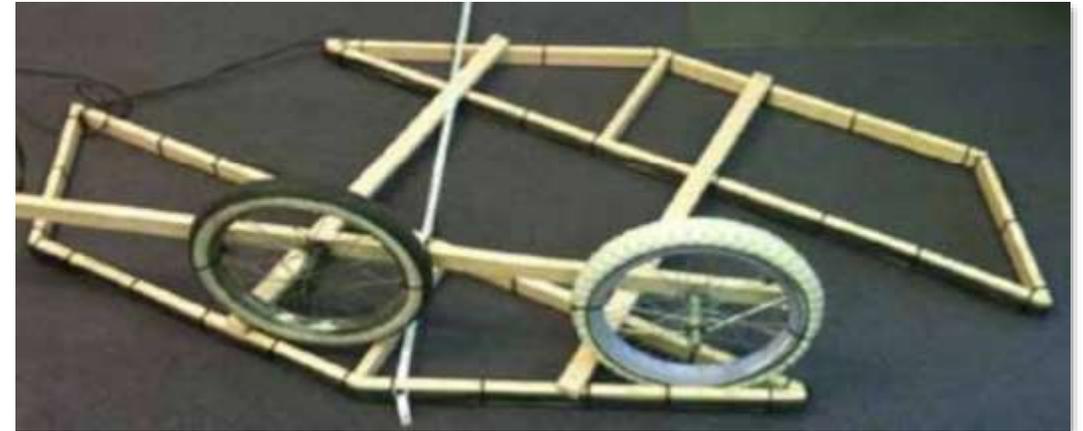
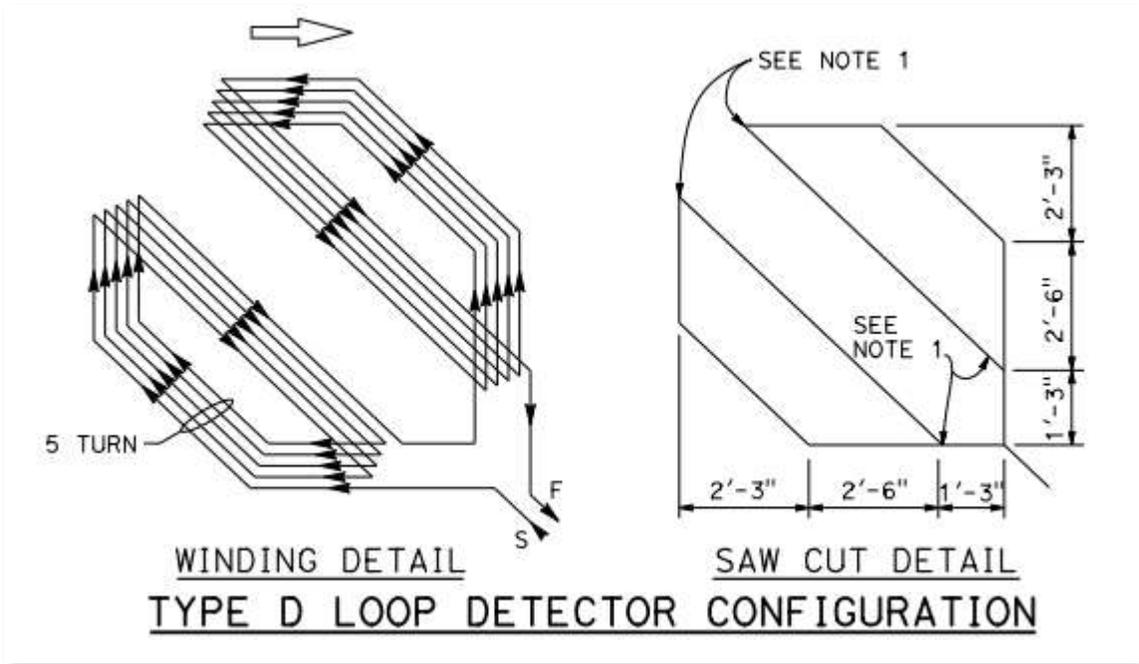
Bike Boxes - Additional Info:

- See National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide: <https://nacto.org/publication/urban-bikeway-design-guide/>
- FHWA Interim Approval 20 (IA-20) for the Optional Use of Two-Stage Bicycle Turn Boxes: https://mutcd.fhwa.dot.gov/res-interim_approvals.htm



Dewey Beach Area Improvements

“D” Loop Bicycle Detector developed by CalTrans





Dewey Beach Area Improvements

“Green” Stormwater Management Improvements:

- Inter-agency coordination with Delaware Center for Inland Bays to include a pilot bio-retention area to reduce storm runoff into the Rehoboth Bay





Dewey Beach Area Improvements

“Green” Stormwater Management Improvements:

- Installation of permeable concrete pavement along select areas of shoulder with historical drainage concerns
- Vacuum truck is used to clean sand and other debris to maintain porosity





Dewey Beach Area Improvements

Next Up for Dewey Beach – Median Pedestrian Barrier Coming this Fall/Winter

- Intended to “funnel” pedestrians to crosswalks and deter mid-block crossings
- Nautical post-and-rope theme
- Removal of existing concrete and new low-level landscaping and mulch
- Installation of 3 twin arm light poles in the SR 1 median from Houston Street to Bayard Ave
- Town Agreement → Town to own and maintain barrier system, landscaping, and additional lighting



Inspiration Photos



Dewey Beach Area Improvements

“Pilot” Median Barrier Project Limits – Saulsbury Street to Read Avenue

- Funded by DeIDOT Traffic with Town and local legislator contributions
- Limits based on historical pedestrian / bicycle crash clusters and adjacent land use
- ~1,500 linear feet
- Future capital or town project could extend barrier system

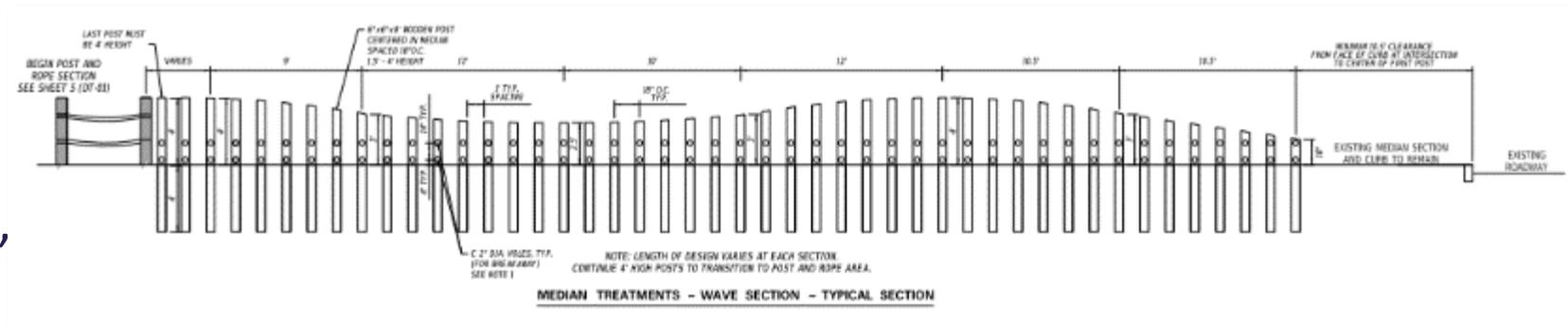
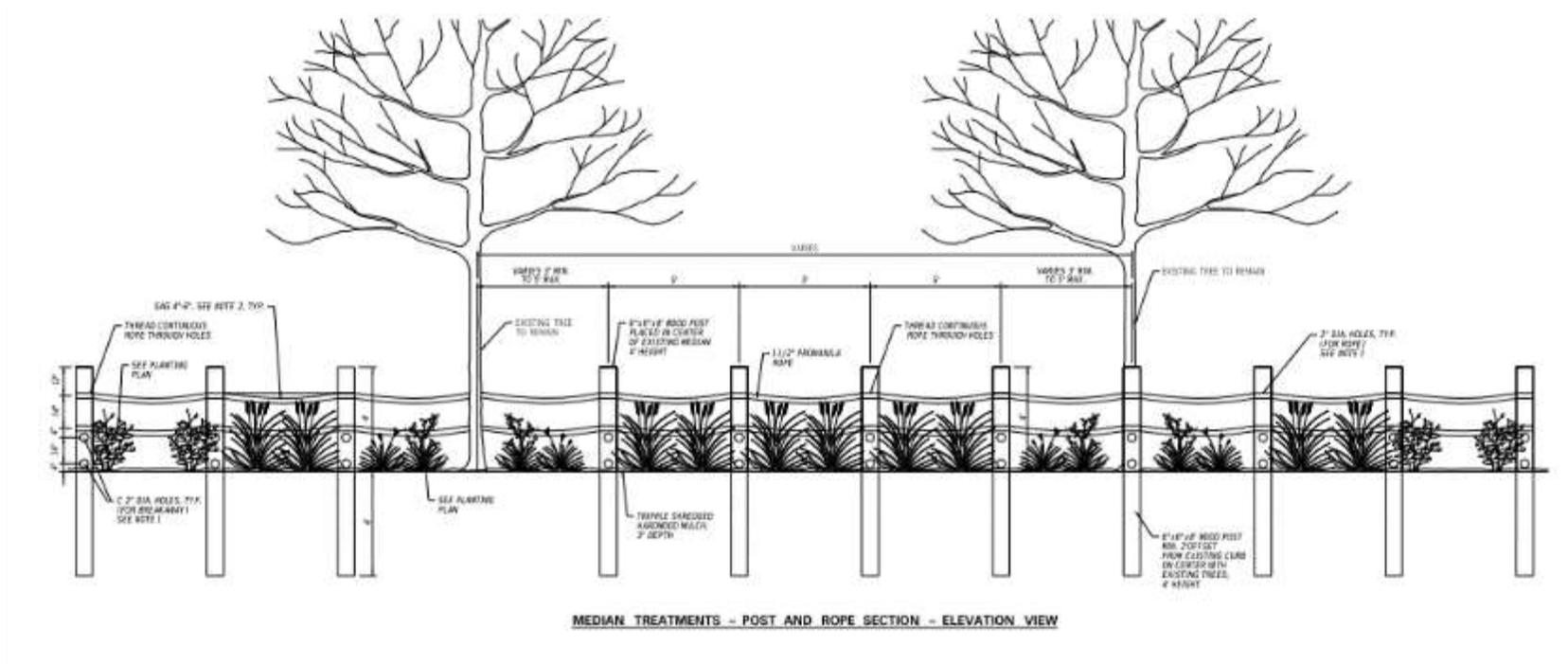




Dewey Beach Area Improvements

“Pilot” Median Barrier Project

- Similar to Florida DOT developmental standard detail
- Utilizes wood posts with holes drilled perpendicular to the direction of travel for breakaway effect
- System is not crash tested, but individual wood posts are NCHRP 350 approved
- Pedestrian safety benefits outweigh rare potential for roadway departure crash (curb, low speeds, urban setting)





Dewey Beach Area Improvements



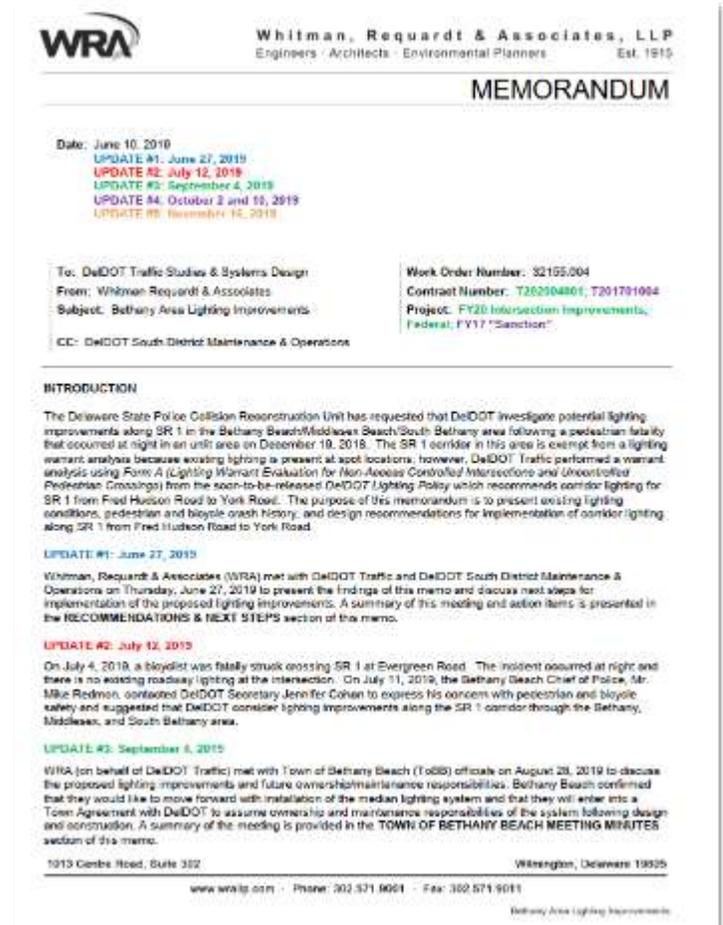
Ongoing Support for the Town of Dewey Beach:

- Lowering speed limit from 30 MPH to 25 MPH, justified by multi-modal safety
- Custom sidewalk stencils to educate and remind pedestrians to check both lanes of traffic (concerns with “multiple threat” scenarios)
- Town agreements to install in-roadway signage and advance “pedestrian crossing” pavement markings at uncontrolled crosswalks
- Educational message boards for motorists to yield at RRFBs
- Future multi-million \$\$\$ capital project (construction FY28)



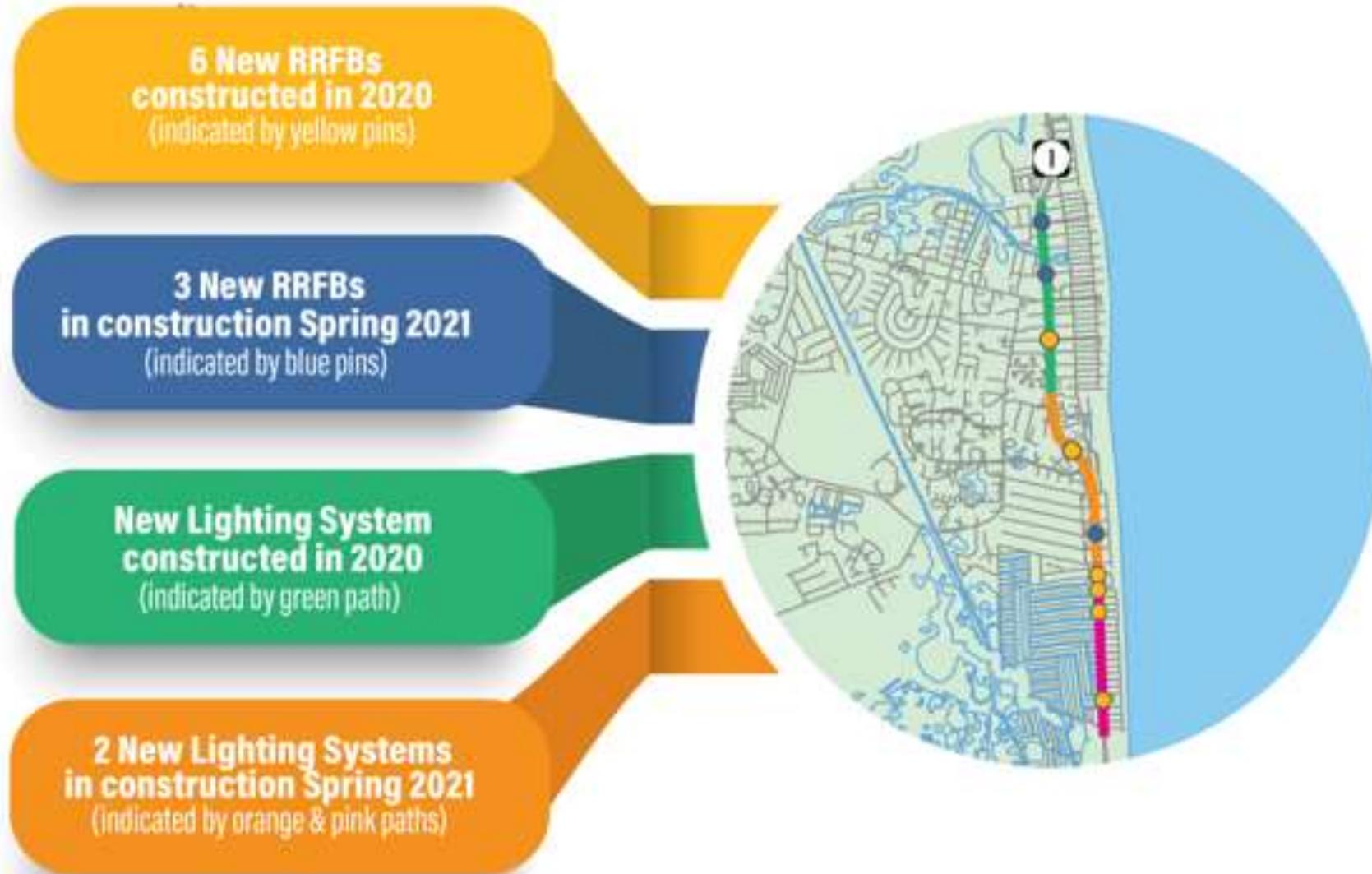
Bethany Area Improvements

- June 2019 → Delaware State Police, Town of Bethany Beach and Town of South Bethany approached DeIDOT
- DeIDOT Traffic and Towns partnered on a 2-year, \$2+ million pedestrian improvement program highlighted by continuous roadway lighting and 9 RRFB crossing systems





Bethany Area Improvements





Bethany Area Improvements

Roadway Lighting:

- Twin arm decorative light standards in the median of SR 1
- Nearly 3 miles of continuous roadway lighting – 87 light poles total
- \$1.56 million total
- 3 separate lighting systems:
 - Town of Bethany Beach
 - Town of South Bethany
 - DeDOT (Middlesex Beach/Sea Colony unincorporated area)





Bethany Area Improvements

Roadway Lighting: Town Agreements and Cost Sharing

- DeIDOT funded design and construction, the Towns assumed ownership and maintenance
- Towns provided additional funding for decorative light poles





Bethany Area Improvements

Town of Bethany Beach – Striping Improvements

- No sidewalks along SR 1 → shoulder serves as defacto pedestrian access route and bike lane
- Installed pedestrian and bicycle markings along the SR 1 shoulders to delineate proper areas/directions of travel, educate road users and enhance the conspicuity of pedestrian crossings and conflict areas





Bethany Area Improvements

RRFB Improvements – Bethany Beach

- 3 new RRFBs installed
 - Wellington Parkway
 - Central Boulevard
 - Oceanview Parkway
- Bethany Beach provided construction funding for one location
- Selected locations based on land use and pedestrian desire lines

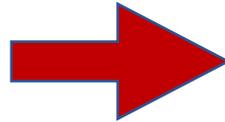




Bethany Area Improvements

RRFB Improvements – Bethany Beach

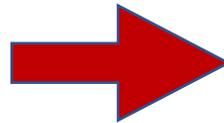
- Roadside constraints required “stealing” existing pavement and shifting crosswalk locations to provide ADA compliant landing areas





Bethany Area Improvements

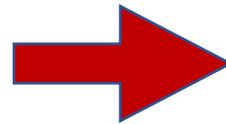
RRFB Improvements – Bethany Beach





Bethany Area Improvements

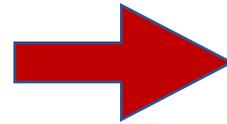
RRFB Improvements – Bethany Beach





Bethany Area Improvements

RRFB Improvements – Bethany Beach





Bethany Area Improvements

RRFB Improvements – Middlesex Beach / Sea Colony

- 2 new RRFBs installed
 - Marketplace / Hickman Plaza
 - Bridge Road



- Locations based on crash data and coordination with Middlesex Beach Association
- Additional RRFBs being considered in Middlesex Beach area for FY22-23



Bethany Area Improvements

RRFB Improvements – South Bethany

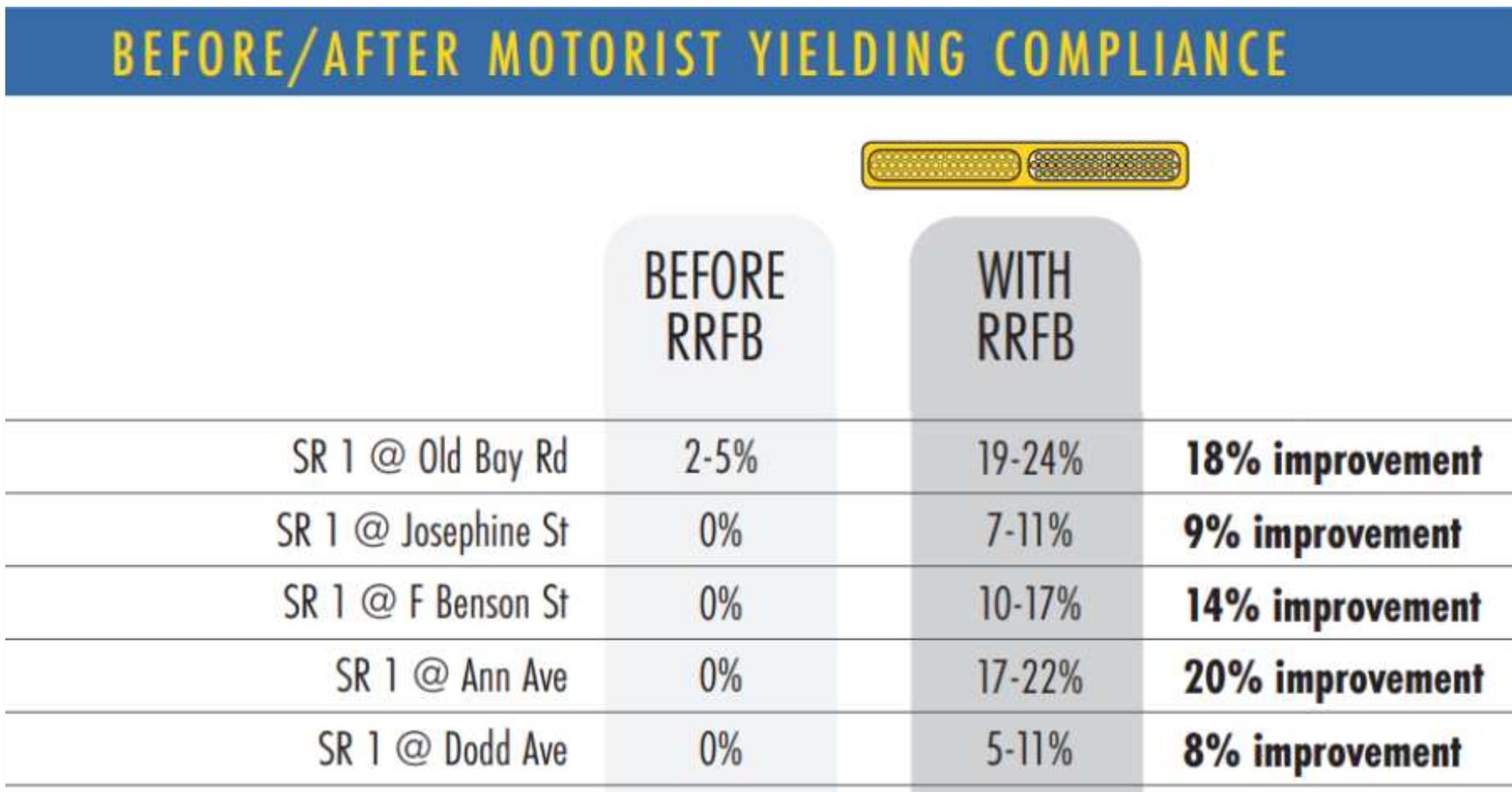
- 4 new RRFBs installed
 - Anchorage Drive
 - Petherton Drive
 - Henlopen Drive
 - Bayshore Drive
- Locations based on land use and pedestrian desire lines
- Locations coordinated with DeIDOT Planning and new bicycle parking racks





RRFB Before and After Data Analysis: Do They Work?

SR 1, Rehoboth Canal to Dewey Beach Northern Limits Results:





RRFB Before and After Data Analysis: Do They Work?

SR 1, Rehoboth Canal to Dewey Beach Northern Limits Results:

Measure of Effectiveness	Before RRFB	After RRFB
Avg # Not Yielding	14	4
Avg Ped Delay (sec)	30	14
Avg # Not Yielding if first vehicle doesn't yield	15	5
Avg Delay if first vehicle doesn't yield (sec)	31	17
Avg Delay, Yield Crossing (sec)	20	13
Avg Delay, Gap Crossing (sec)	31	16
% Yield Crossings	8%	46%
% Gap Crossings	92%	54%
% First Vehicle Yields	2%	18%



RRFB Before and After Data Analysis: Do They Work?

SR 1, Town of Dewey Beach Results:

BEFORE/AFTER MOTORIST YIELDING COMPLIANCE

	BEFORE RRFB	WITH RRFB	
SR 1 @ St. Louis St	2-11%	26-52%	33% improvement
SR 1 @ Clayton St	5%	32-50%	36% improvement
SR 1 @ Swedes St	0-9%	40-48%	40% improvement
SR 1 @ New Orleans St	8-9%	40-50%	37% improvement
SR 1 @ Dagsworthy St	7-8%	38-48%	36% improvement
SR 1 @ McKinley St	3-11%	20-27%	17% improvement
SR 1 @ Rodney Ave	3-11%	34-30%	33% improvement
SR 1 @ Van Dyke St	10-15%	34-30%	25% improvement



RRFB Before and After Data Analysis: Do They Work?

SR 1, Town of Dewey Beach Results:

Measure of Effectiveness	Before RRFB	After RRFB
Avg # Not Yielding	4	2
Avg Ped Delay (sec)	16	8
Avg # Not Yielding if first vehicle doesn't yield	5	4
Avg Delay if first vehicle doesn't yield (sec)	17	11
Avg Delay, Yield Crossing (sec)	14	7
Avg Delay, Gap Crossing (sec)	17	10
% Yield Crossings	15%	87%
% Gap Crossings	85%	13%
% First Vehicle Yields	7%	39%



RRFB Before and After Data Analysis: Do They Work?

SR 1, Bethany Area Results:

BEFORE/AFTER MOTORIST YIELDING COMPLIANCE			
	BEFORE RRFB	WITH RRFB	
SR 1 @ Oceanview Pkwy	11-19%	48-53%	36% improvement
SR 1 @ Central Blvd	15-17%	40-48%	28% improvement
SR 1 @ Bridge Rd	13-20%	38-51%	40% improvement
SR 1 @ Wellington Pkwy	3-12%	53-60%	49% improvement
SR 1 @ Anchorage Dr	0-2%	16-45%	30% improvement
SR 1 @ Petherton Dr	0-3%	34-46%	39% improvement
SR 1 @ Henlopen Dr	5-12%	45-48%	38% improvement
SR 1 @ Bayshore Dr	10-13%	40-50%	34% improvement



RRFB Before and After Data Analysis: Do They Work?

SR 1, Bethany Area Results:

Measure of Effectiveness	Before RRFB	After RRFB
Avg # Not Yielding	4	2
Avg Ped Delay (sec)	14	8
Avg # Not Yielding if first vehicle doesn't yield	4	3
Avg Delay if first vehicle doesn't yield (sec)	15	11
Avg Delay, Yield Crossing (sec)	9	7
Avg Delay, Gap Crossing (sec)	15	12
% Yield Crossings	22%	86%
% Gap Crossings	78%	14%
% First Vehicle Yields	10%	45%



RRFB Before and After Data Analysis: Do They Work?

Beach Area Data vs. Statewide Delaware Data vs. Past TTI Studies

First Vehicle Yielding Compliance Rates			
Location	Before RRFB	After RRFB	Improvement
SR 1, Rehoboth Canal to Dewey Beach	2%	18%	16%
SR 1, Town of Dewey Beach	7%	39%	32%
SR 1, Bethany Area	10%	45%	35%
Delaware Statewide (15 other sites)	15%	46%	34%
Florida 2010 Study	4%	72-96%	80%
Oregon 2011 Study	2-25%	74-83%	63%
Michigan 2014	20%	69%	49%
Texas 2014	<1-28%	37-89%	49%

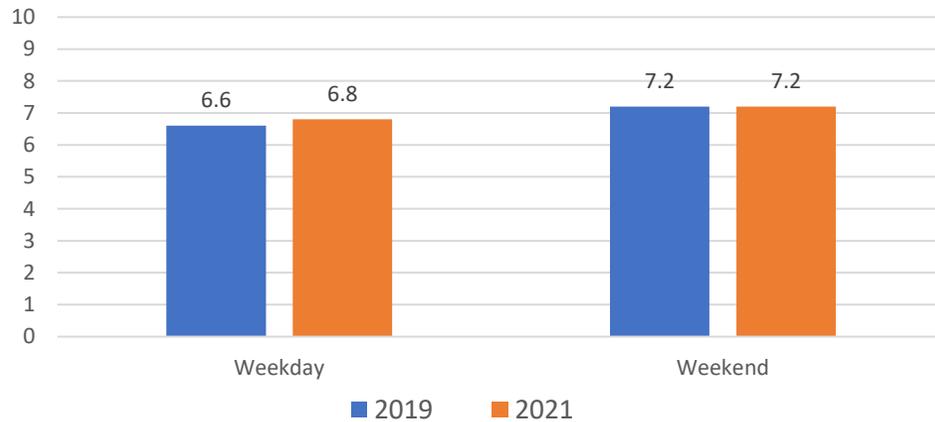


RRFB Before and After Data Analysis: Do They Work?

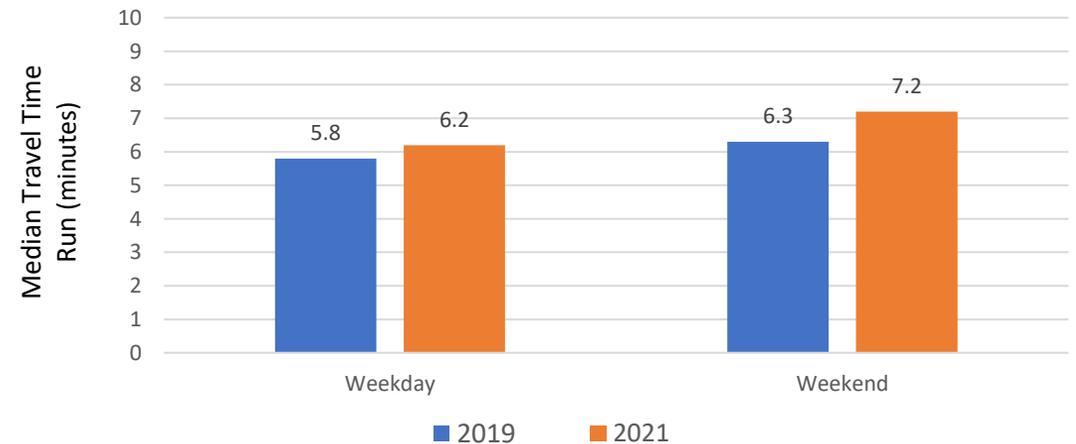
How do the RRFBs Affect Corridor Travel Times?

Dewey Beach Bluetooth Data – Summer 2019 vs. Summer 2021

SR 1 Northbound Dewey Beach Median Travel Time Runs - Collins Avenue to Rehoboth Avenue



SR 1 Southbound Dewey Beach Median Travel Time Runs - Collins Avenue to Rehoboth Avenue



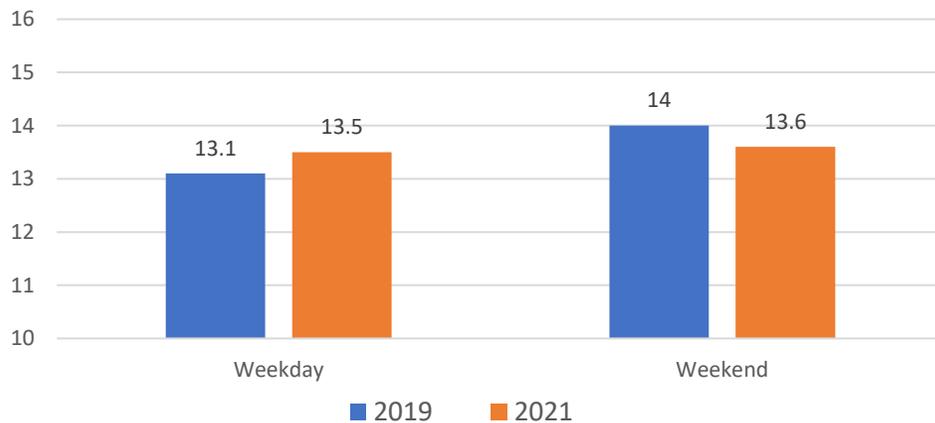


RRFB Before and After Data Analysis: Do They Work?

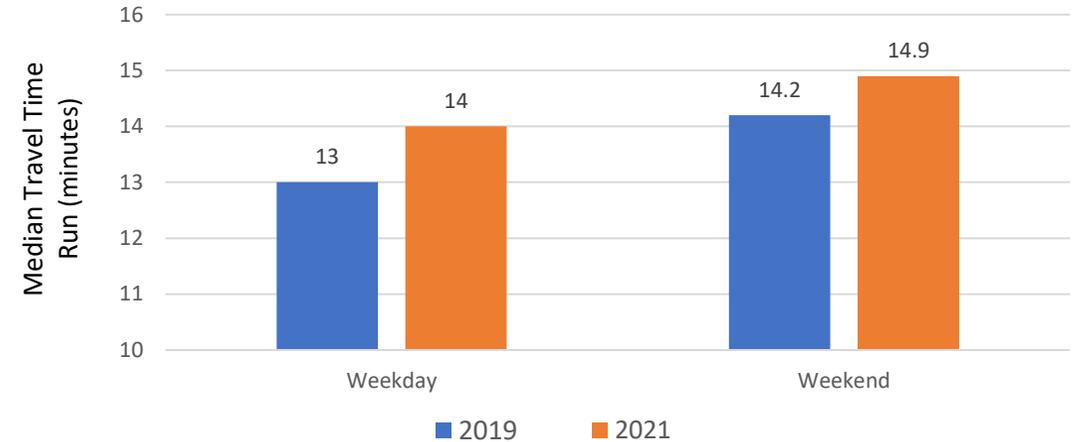
How do the RRFBs Affect Corridor Travel Times?

Bethany Area Bluetooth Data – Summer 2019 vs. Summer 2021

SR 1 Northbound Bethany Area Median Travel Time Runs - Fred Hudson Road to SR 54



SR 1 Southbound Bethany Area Median Travel Time Runs - Fred Hudson Road to SR 54





RRFB Before and After Data Analysis: Do They Work?

RRFB Before/After Data – Conclusions:

- RRFBs have been generally well received by the communities
- Data is positive and verifies improvement in driver yielding compliance
- Average pedestrian delay has been cut in half
- Significant improvement in % of yield crossings vs. gap crossings
- Dewey Beach and Bethany Area RRFBs generally align with statewide yielding rates
- Rehoboth Canal to Dewey Beach area underperformed in first vehicle yielding rate, but saw significant improvement in average not yielding (14 to 4) and % of yield crossings (8% to 46%)



RRFB Evaluation and Design Considerations

Pedestrian Crossing Evaluation and Study Process - Field Evaluation:

- Yielding compliance and pedestrian delay calculations (typically 25 readings for each crossing direction - see next slide for example)
- Vehicular speed studies for each main street approach (typically 50 readings per direction)
- Spot counts for ped/bike crossing volumes and main street vehicular volumes
- Sight distance evaluation
- Evaluate feasibility for geometric improvements (e.g., refuge islands, curb bumpouts) to reduce crossing distance and conflict points
- ADA design considerations (e.g., level landing areas, pole base locations, pushbutton oriented parallel with crosswalk, 18" turning space extension, pedestrian network, etc.)
- Power availability – hard-wired vs. solar-powered
- Utility and/or right-of-way constraints



RRFB Evaluation and Design Considerations

Example “Staged” Crossing Study for Vehicle Yielding Compliance and Pedestrian Delay

Location:			Date:			Start & End Time:		
Direction: Northbound			EAST --> WEST CROSSING					
Crossing Number	Crossing Northbound Traffic			Crossing Southbound Traffic			Comments	
	Number that Don't Yield	Gap or Yield	Ped Delay (seconds)	Number that Don't Yield	Gap or Yield	Ped Delay (seconds)		
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

Procedure:

- Requires 2 people – 1 “pedestrian” and 1 recorder/stopwatch operator
- The “pedestrian” should wear inconspicuous clothing (i.e., no vests/PPE) to appear as a civilian
- The “pedestrian” steps up to the edge of curb when a platoon of vehicles in the near-side lane is approaching the stopping sight distance for the posted speed
- The recorder begins the stopwatch when the pedestrian steps to the curb and stops once a near-side vehicle yields or there is a sufficient gap to cross.
- Record the number of vehicles that did not yield, whether the crossing was made due to a gap or yield, and the seconds of pedestrian delay
- If no vehicles are present in the opposing lane, leave the columns under the opposite direction of travel blank → “single stage crossing”
- If nearside vehicles yield but traffic is approaching in the far lane, the recorder shall “lap” the stopwatch and record the same data for the opposite direction of travel → “two stage crossing”



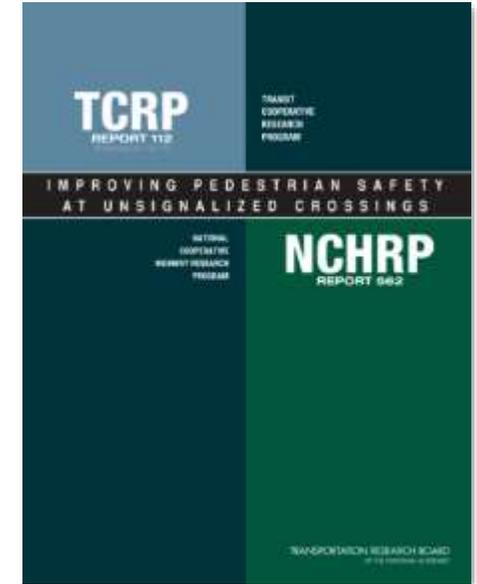
RRFB Evaluation and Design Considerations

Pedestrian Crossing Evaluation and Study Process - Office Evaluation:

- Crash data analysis → specific trends attributed to the crossing?
- NCHRP Report 562 Analysis for pedestrian crossing treatment recommendation
- Process data from field pedestrian crossing studies and speed studies
- Archive plan research for existing utility and right-of-way information → identify any major impacts before proceeding with final design

WORKSHEET 1: PEAK-HOUR, 35 MPH (55 KM/H) OR LESS	
Analyst and Site Information	
Analyst:	Major Street:
Analysis Date:	Minor Street or Location:
Data Collection Date:	Peak Hour:
Step 1: Select worksheet (speed reflects posted or statutory speed limit or 85 th percentile speed on the major street): a) Worksheet 1 – 35 mph (55 km/h) or less b) Worksheet 2 – exceeds 35 mph (55 km/h), communities with less than 10,000, or where major transit stop exists	
Step 2: Does the crossing meet minimum pedestrian volumes to be considered for a TCD type of treatment?	
Peak-hour pedestrian volume (ped/h), V_p	2a
If $2a \geq 20$ ped/h, then go to Step 3. If $2a < 20$ ped/h, then consider median refuge islands, curb extensions, traffic calming, etc. as feasible.	
Step 3: Does the crossing meet the pedestrian volume warrant for a traffic signal?	
Major road volume, total of both approaches during peak hour (veh/h), V_{maj}	3a
Minimum signal warrant volume for peak hour (use 3a for V_{maj}), SC SC = $(0.00021 V_{maj}^2 - 0.74072 V_{maj} + 734.125)/0.75$ OR $[(0.00021 3a^2 - 0.74072 3a + 734.125)/0.75]$	3b
If $3b < 133$, then enter 133. If $3b \geq 133$, then enter 3b.	3c
If 15 th percentile crossing speed of pedestrians is less than 3.5 ft/s (1.1 m/s), then reduce 3c by up to 50 percent; otherwise enter 3c.	3d
If $2a \geq 3d$, then the warrant has been met and a traffic signal should be considered if not within 300 ft (91 m) of another traffic signal. Otherwise, the warrant has not been met. Go to Step 4.	
Step 4: Estimate pedestrian delay.	
Pedestrian crossing distance, curb to curb (ft), L	4a
Pedestrian walking speed (ft/s), S_p	4b
Pedestrian start-up time and end clearance time (s), t_s	4c
Critical gap required for crossing pedestrian (s), $t_c = (L/S_p) + t_s$ OR $[(4a/4b) + 4c]$	4d
Major road volume, total both approaches or approach being crossed if median refuge island is present during peak hour (veh/h), V_{maj}	4e
Major road flow rate (veh/s), $v = V_{maj}/3600$ OR $[4e/3600]$	4f
Average pedestrian delay (s/person), $d_p = (e^{v t_c} - v t_c - 1) / v$ OR $[e^{4f \times 4d} - 4f \times 4d - 1] / 4f$	4g
Total pedestrian delay (h), $D_p = (d_p \times V_p)/3,600$ OR $[(4g \times 2a)/3600]$ (this is estimated delay for all pedestrians crossing the major roadway without a crossing treatment – assumes 0% compliance). This calculated value can be replaced with the actual total pedestrian delay measured at the site.	4h
Step 5: Select treatment based upon total pedestrian delay and expected motorist compliance.	
Expected motorist compliance at pedestrian crossings in region, Comp = high or low	5a
Total Pedestrian Delay, D_p (from 4h) and Motorist Compliance, Comp (from 5a)	Treatment Category (see Descriptions of Sample Treatments for examples)
$D_p \geq 21.3$ h (Comp = high or low) OR 5.3 h $\leq D_p < 21.3$ h and Comp = low	RED
1.3 h $\leq D_p < 5.3$ h (Comp = high or low) OR 5.3 h $\leq D_p < 21.3$ h and Comp = high	ACTIVE OR ENHANCED
$D_p < 1.3$ h (Comp = high or low)	CROSSWALK

Figure A-2. Worksheet 1.



Key Data Inputs for NCHRP 562 Analysis:

- Pedestrian crossing volumes
- Major road volumes
- Pedestrian crossing distance
- Pedestrian walking speed (3.5 ft/sec per MUTCD)
- Pedestrian start-up time = 3 sec per HCM



RRFB Design Considerations

Typical Hardwired Power Feed / Cabinet Setup





RRFB Design Considerations

Example municipally-funded solar RRFB setups





RRFB Design Considerations

Cost Estimating for RRFB Systems:

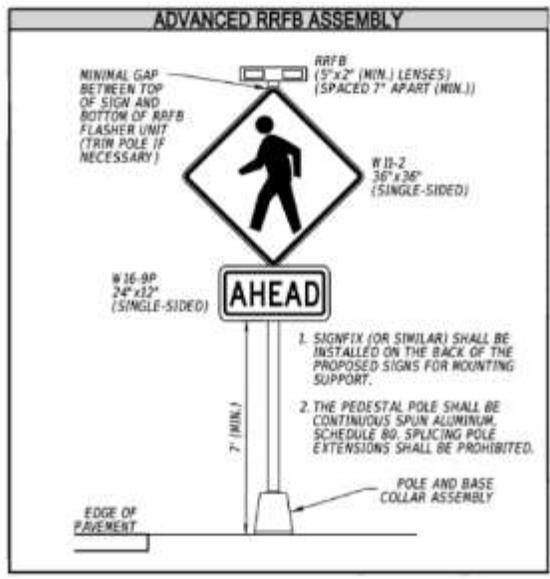
- Solar-powered assemblies
 - ~ \$8,000-\$12,000 total per pole/flasher
- Hardwired assemblies
 - ~\$6,000 per pole/flasher assembly
 - \$25,000 - \$35,000 total for simple single stage crossing with 2 pole/flasher assemblies including underground infrastructure and minor ADA upgrades
 - \$45,000 - \$65,000 for 2-stage crossings with 3-4 pole/flasher assemblies including underground infrastructure and minor ADA upgrades



RRFB Design Considerations

Outside-the-Box RRFB Accommodations – Advance Flashers for Poor Sight Distance

- Developer-funded trail crossing on Camp Arrowhead Road near Long Neck, DE
- Horizontal geometry limits sight distance for pedestrian crossing
- The pushbuttons at the crossing location will activate advance “AHEAD” flashers to actively warn approaching motorists of pedestrian activity





RRFB Design Considerations

Interim / Low-Cost Alternative Countermeasures

- “Spin Alert” hazard warning device
- Not recognized by MUTCD as a traffic control device – limited experimental use in DE
- Pilot location study – Beaver Dam Rd at St. Georges Chapel near Lewes, DE
 - Immediately following installation, driver compliance improved from 0-9% to 33-64%
 - Six months later, compliance rates decreased to 16-26%, but still an improvement over pre-existing conditions



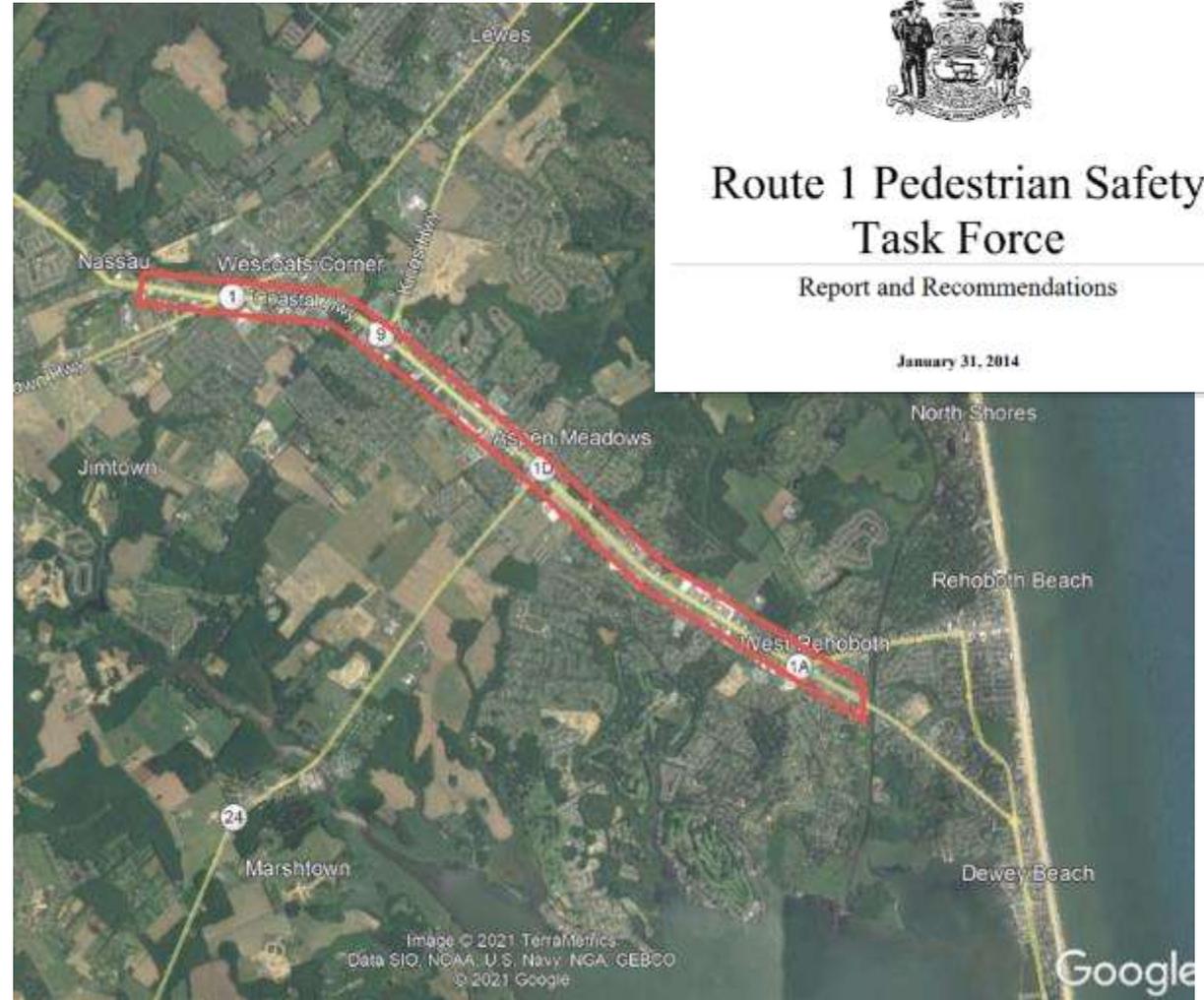


Pedestrian Safety Countermeasures in Action – Pedestrian Hybrid Beacons (HAWKs) in Lewes/Rehoboth Beach Area



Lewes and Rehoboth Beach Area Improvements

- SR 1 – Rehoboth Canal to North of US 9 (Five Points) Pedestrian Improvements
 - July 2013 → DeIDOT and legislators formed the Route 1 Ped Safety Task Force to develop recommendations and form project scope
 - \$7 million construction budget
 - Project completed spring 2016





Lewes and Rehoboth Beach Area Improvements

- SR 1 – Rehoboth Canal to North of US 9 (Five Points) Pedestrian Improvements
 - Project elements included:
 - 6 miles of continuous sidewalk along both sides of SR 1
 - 6 new signalized crossings of SR 1
 - 2 new HAWK beacons
 - Lighting Improvements
 - Bus/Bike/Right-Turn Lane Signing and Striping
 - Transit improvements





Lewes and Rehoboth Beach Area Improvements

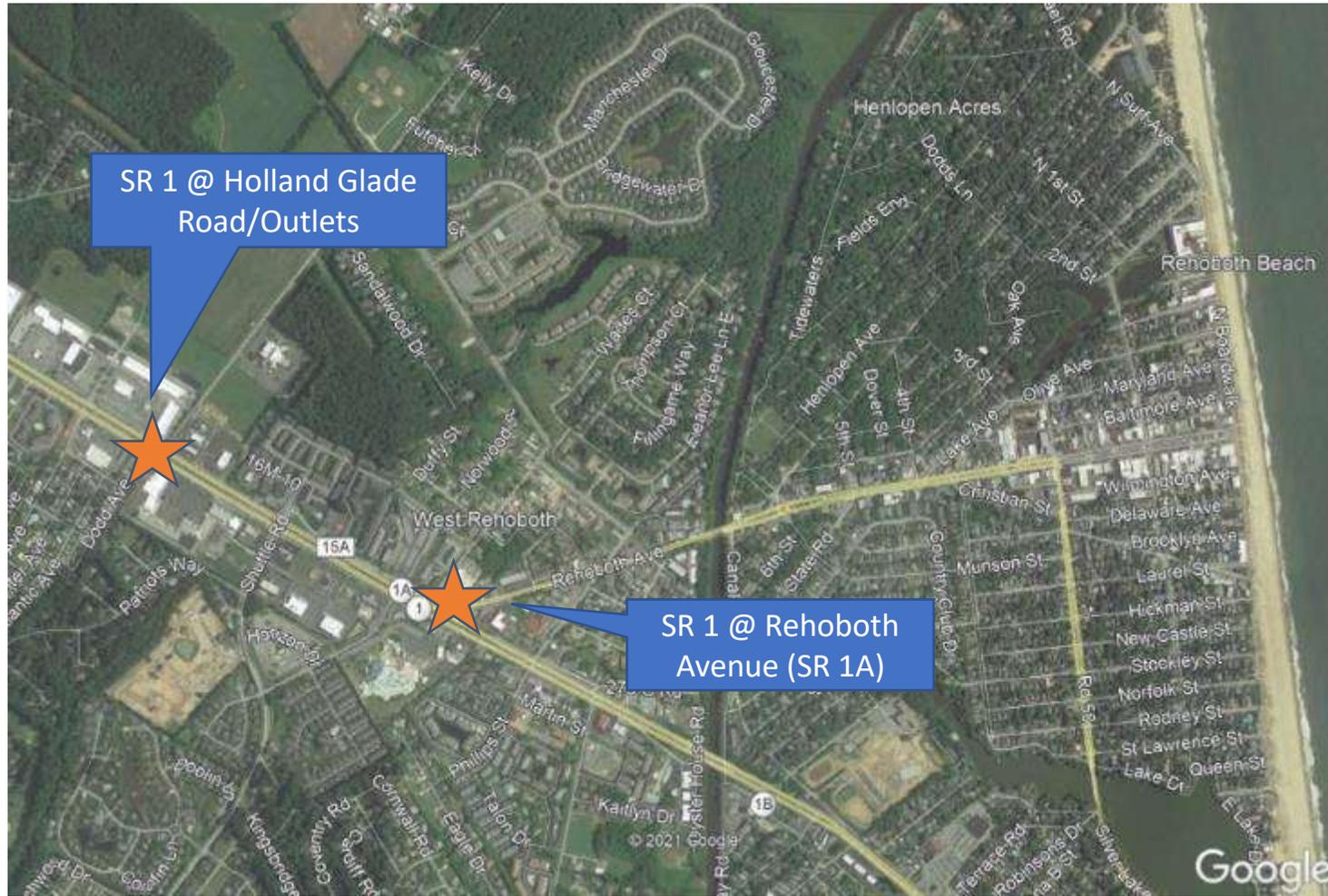
Pedestrian Hybrid Beacons (HAWK) – How do they Operate?





Lewes and Rehoboth Beach Area Improvements

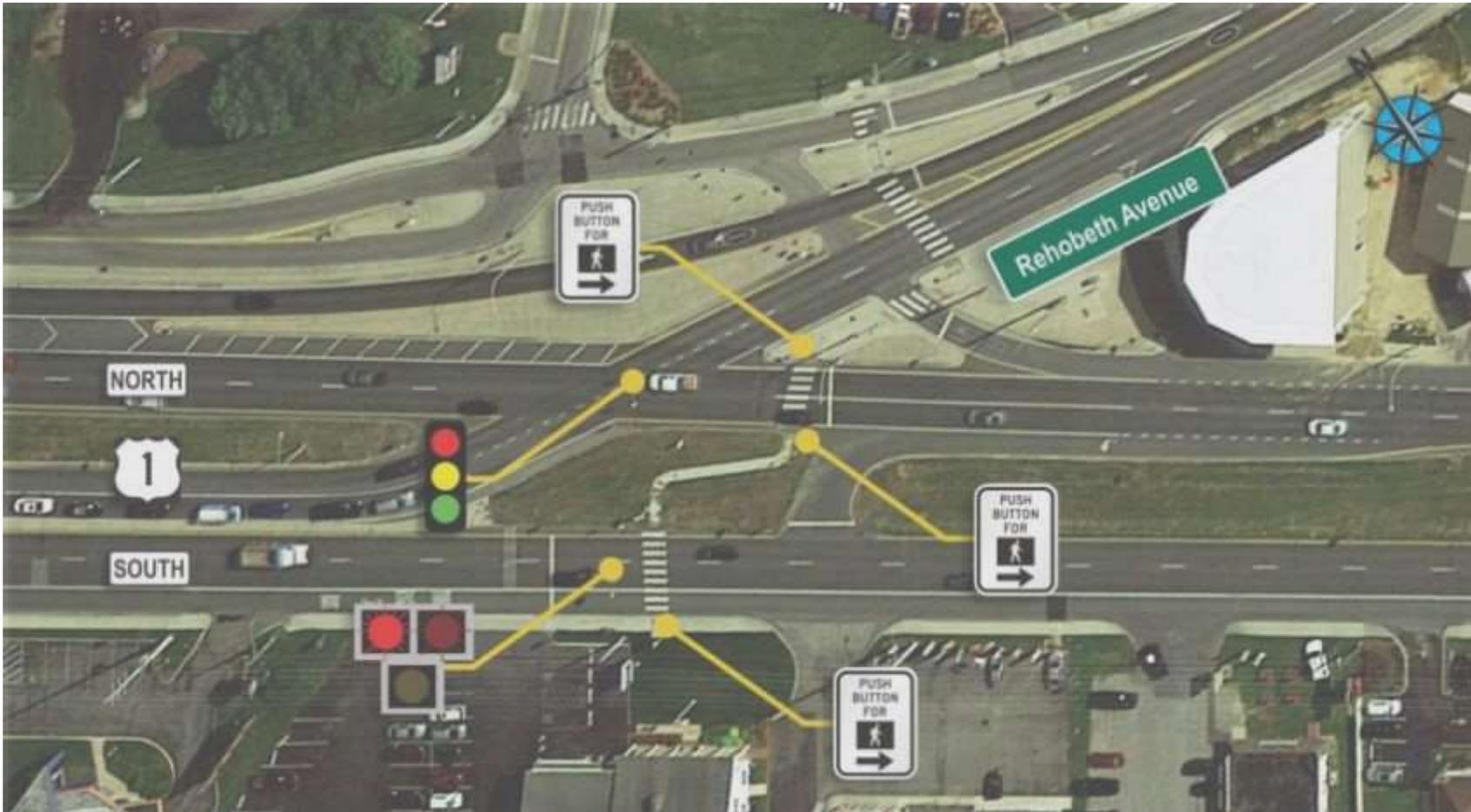
SR 1 HAWK Signal Locations





Lewes and Rehoboth Beach Area Improvements

Pedestrian Hybrid Beacons (HAWK) -SR 1 @ Rehoboth Avenue (SR 1 SB only)

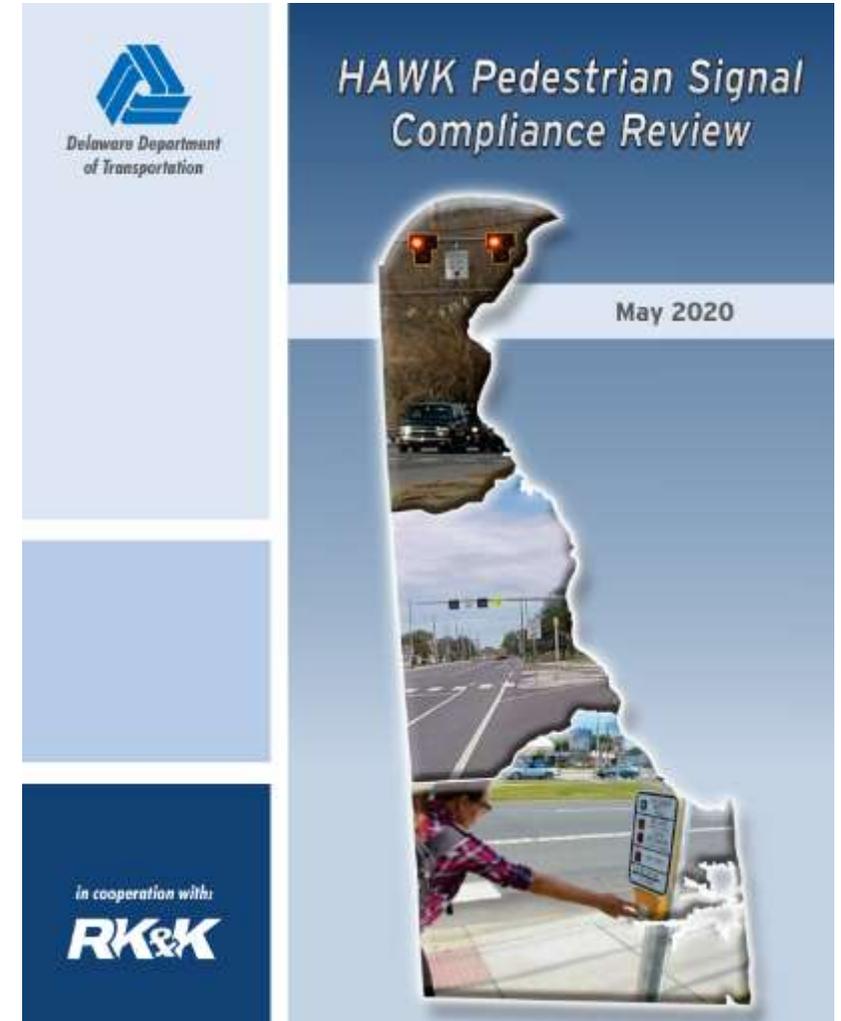




Lewes and Rehoboth Beach Area Improvements

DelDOT HAWK Pedestrian Signal Compliance Review

- SR 1 at Rehoboth Avenue:
 - Motorist Compliance down from 87% in 2016 to 59% in 2019
 - Pedestrians and bicyclists frequently activate HAWK, but cross before the HAWK signal activates. Subsequently, many non-complying vehicles observed when no pedestrians or bicyclists are present
 - Total crashes have increased by 27% since installation
 - Zero bike/ped crashes prior to installation; 1 pedestrian and 3 bicycle crashes since installation, although none attributable to the HAWK signal
 - Westbound pedestrians less likely to wait for the HAWK signal to activate and cross properly after completing 3 previous stages of the crossing (4-stage crossing of SR 1 / SR 1A)





Lewes and Rehoboth Beach Area Improvements

HAWK Compliance Review Data – SR 1 @ Rehoboth Avenue Motor Vehicle Compliance

HAWK Compliance Study		Table 7: Southbound SR 1 at Rehoboth Avenue Motor Vehicle Compliance							May 2020
Year	Vehicle Stopped for signal	Vehicle Arrival			Vehicle Departure				
		During All-red	During Walk	During Flashing Red	Correct Action	Incorrect Action			
					Vehicle Proceeded on Flashing Red	Vehicle Proceeded After Ped Cleared Crosswalk	Vehicle Proceeded During Dark Signal	Motorist Appeared Confused*	
2016	87%	9%	2%	2%	22%	6%	70%	2%	
2017	72%	7%	1%	20%	63%	11%	25%	1%	
2019	59%	10%	4%	27%	68%	20%	12%	0%	

*Instances where the motorist waits an excessive amount of time after the signal goes dark before proceeding



Lewes and Rehoboth Beach Area Improvements

HAWK Compliance Review Data – SR 1 @ Rehoboth Avenue Pedestrian Compliance + Control Site Comparison

HAWK Compliance Study May 2020								
Table 8: Control Sites Similar to HAWK Signal at SR 1 and Rehoboth Avenue Pedestrian Compliance								
Location	Crossed Correctly		Crossed Incorrectly					
	Crossed Correctly		Crossed Early		Crossed Late		Never Activated	
	# (%)	Delay (Sec.)	# (%)	Delay (Sec.)	# (%)	Delay (Sec.)	# (%)	Delay (Sec.)
Rehoboth Ave (Peds crossing EB)	29 (56%)	57	9 (17%)	34	0	N/A	14 (27%)	6
Rehoboth Ave (Peds crossing WB)	10 (34%)	57	11 (38%)	32	0	N/A	8 (28%)	9
SR 1 at Westway Drive	71 (65%)	44	12 (11%)	30	14 (13%)	0	12 (11%)	5
SR 1 at Evergreen Road	41 (67%)	45	8 (13%)	30	1 (2%)	0	11 (18%)	4

HAWK Signal
 Traditional Signal



Lewes and Rehoboth Beach Area Improvements

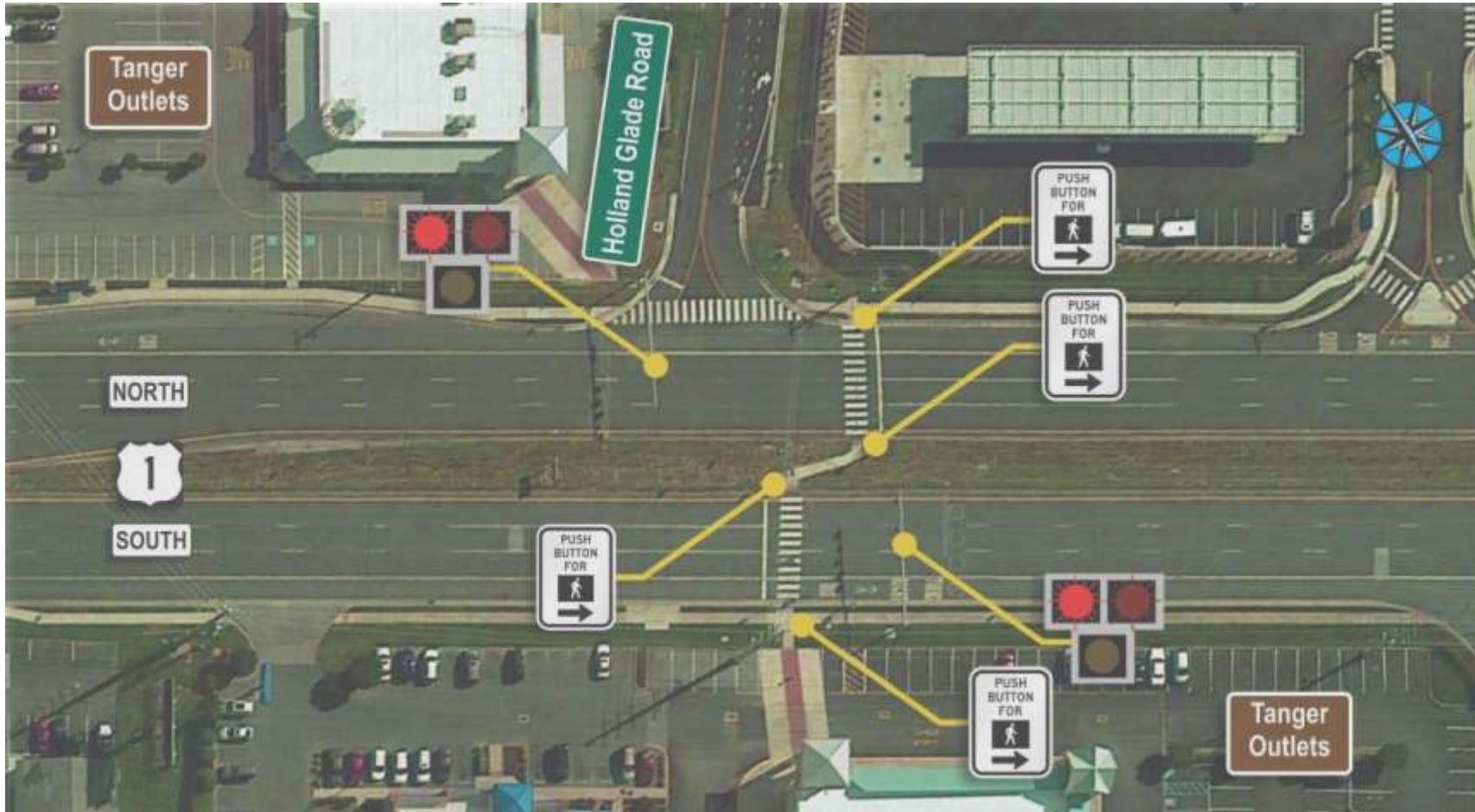
HAWK Compliance Review Data – SR 1 @ Rehoboth Avenue Before/After Crash Analysis

HAWK Compliance Study		May 2020
Table 10: SR 1 at Rehoboth Avenue Before/After Crash Analysis		
Crash Type	Crashes Before Installation	Crashes After Installation
Property Damage Only Crashes	20	28
Personal Injury Crashes	6	5
Fatal Crashes	0	0
Total Crashes	26	33
Total Pedestrian/Bicyclist Crashes	0	1 P, 3 B
Total HAWK-Related Crashes	-	0



Lewes and Rehoboth Beach Area Improvements

Pedestrian Hybrid Beacon (HAWK) - SR 1 @ Holland Glade Road

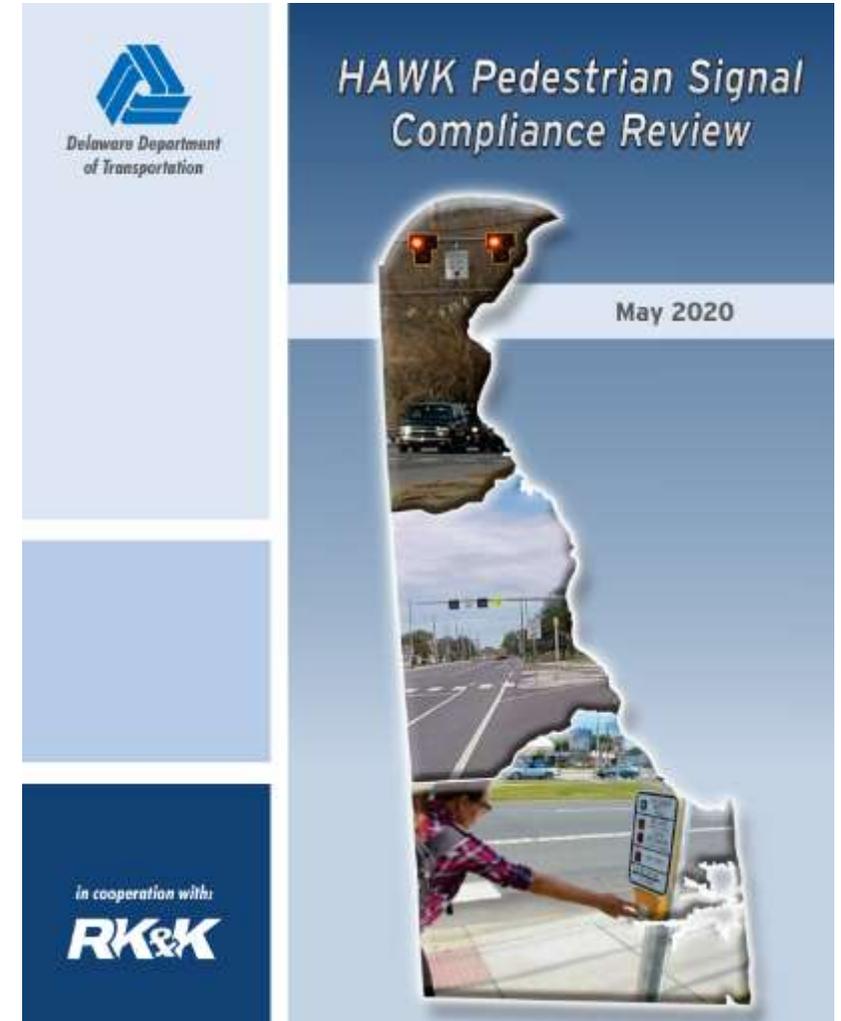




Lewes and Rehoboth Beach Area Improvements

DelDOT HAWK Pedestrian Signal Compliance Review

- SR 1 at Holland Glade Road:
 - Motorist Compliance down from 97% in 2016 to 72% in 2019
 - Pedestrians and bicyclists frequently activate HAWK, but cross before the HAWK signal activates. Subsequently, many non-complying vehicles observed when no pedestrians or bicyclists are present
 - Motorists observed speeding up during flashing yellow to “beat the light”
 - Total crashes have increased from 29 to 62 since installation of the HAWK
 - Bicycle crashes increased from 1 to 8 since installation of the HAWK signal, including one involving a bicyclist being hit by a motorist that disregarded the signal and 3 other crashes attributed to the HAWK





Lewes and Rehoboth Beach Area Improvements

HAWK Compliance Review Data – SR 1 @ Holland Glade Road / Bayside Outlets Motor Vehicle Compliance

HAWK Compliance Study								May 2020	
Table 11: SR 1 at Holland Glade Road Motor Vehicle Compliance									
		Vehicle Arrival			Vehicle Departure				
Year	Vehicle Stopped for signal	Vehicle Disregarded signal (During Pedestrian Phase)			Correct Action		Incorrect Action		Motorist Appeared Confused*
		During All-red	During Walk	During Flashing Red	Vehicle Proceeded on Flashing Red	Vehicle Proceeded After Ped Cleared Crosswalk	Vehicle Proceeded During Dark Signal		
2016	97%	3%	0%	0%	27%	17%	56%	0%	
2017	78%	6%	1%	15%	57%	15%	27%	1%	
2019	72%	7%	2%	19%	68%	20%	11%	1%	

*Instances where the motorist waits an excessive amount of time after the signal goes dark before proceeding



Lewes and Rehoboth Beach Area Improvements

HAWK Compliance Review Data – SR 1 @ Holland Glade Road / Bayside Outlets
 Pedestrian Compliance + Control Site Comparison

HAWK Compliance Study								May 2020	
Table 12: Control Sites Similar to HAWK Signal at SR 1 and Holland Glade Road Pedestrian Compliance									
	Crossed Correctly		Crossed Incorrectly						
Location	Crossed Correctly		Crossed Early		Crossed Late		Never Activated		
	# (%)	Delay (Sec.)	# (%)	Delay (Sec.)	# (%)	Delay (Sec.)	# (%)	Delay (Sec.)	
Holland Glade Rd (Crossing 1)	61 (81%)	86	11 (15%)	46	1 (1%)	0	2 (3%)	0	
Holland Glade Rd (Crossing 2)	48 (64%)	65	7 (9%)	25	12 (16%)	0	8 (11%)	2	
SR 58 at Deltech (Crossing 1)	27 (61%)	53	8 (18%)	46	0	0	9 (21%)	0	
SR 58 at Deltech (Crossing 2)	28 (64%)	59	8 (18%)	16	0	0	8 (18%)	3	

HAWK Signal
 Traditional Signal



Lewes and Rehoboth Beach Area Improvements

HAWK Compliance Review Data – SR 1 @ Holland Glade Road / Bayside Outlets
Before/After Crash Analysis

HAWK Compliance Study		May 2020
Table 14: SR 1 at Holland Glade Road Before/After Crash Analysis		
Crash Type	Crashes Before Installation	Crashes After Installation
Property Damage Only Crashes	24	49
Personal Injury Crashes	5	13
Fatal Crashes	0	0
Total Crashes	29	62
Total Pedestrian/Bicyclist Crashes	1 B	8 B
Total HAWK-Related Crashes	-	4



Lewes and Rehoboth Beach Area Improvements

SR 1 HAWKs – Examples of Non-Compliance and Confusion





Lewes and Rehoboth Beach Area Improvements

SR 1 HAWKs – Examples of Non-Compliance and Confusion



Figure 8: Examples of conflicts at SR 1 and Holland Glade Road HAWK Signal



Lewes and Rehoboth Beach Area Improvements

Recommendations and Next Steps for SR 1 HAWK Signals:

- Recommended that HAWK signals no longer be installed at *intersections* in Delaware – does not apply to HAWK signals installed at mid-block locations
- Recommended that HAWKS only be installed at locations that can accommodate a single-stage pedestrian crossing. HAWK signal should not be installed at locations with wide medians requiring a two-stage crossing
- DelDOT will monitor studies related to and consider the use of passive detectors at HAWK signals, which can pre-activate signals, extend walk interval for slower pedestrians, and shorten walk intervals or cancel calls if pedestrians leave early
- Removal of the HAWK signals and replacement with traditional full color traffic signals are proposed for both SR 1 Rehoboth Beach area locations



Strategies & Actions for Improving Pedestrian Safety



Strategies & Actions for Improving Pedestrian Safety

- Strategy 1: Develop and distribute consistent public information messages to educate the public about pedestrian safety
 - Increase targeted public outreach, based on specific data-driven trends
 - Increase awareness regarding pedestrian infrastructure improvements and incorporate educational outreach in conjunction with implementation of pedestrian improvement projects
 - Develop and distribute targeted public information messages to increase public awareness regarding safety issues during vehicle breakdowns
- Strategy 2: Develop educational training programs to improve pedestrian safety awareness
 - Incorporate pedestrian (and other road user) laws and rules of the road into Drivers Education and Defensive Driving curricula
 - Develop an educational outreach program for school children targeting pedestrian safety issues
 - Develop and implement formal crossing guard certification requirements, similar to programs for flaggers in highway work zones



Strategies & Actions for Improving Pedestrian Safety

- Strategy 3: Strengthen pedestrian safety laws and enforcement efforts
 - Utilize a strategic law enforcement and social services approach to address substance abuse related to pedestrian crashes and behaviors
 - Conduct high-visibility enforcement campaigns targeting both pedestrians and drivers to promote pedestrian safety
 - Support expansion of legislation permitting the use of automated speed enforcement in Delaware
 - Evaluate the need for a “Pedestrian Safety Behavior Modification” class and require those charged with various pedestrian safety violations to participate in the class



Strategies & Actions for Improving Pedestrian Safety

- Strategy 4: Install effective engineering countermeasures to improve pedestrian safety
 - Continue conducting pedestrian safety audits at high-crash locations and critical corridors and incorporate pedestrian behavioral surveys into the audits
 - Install infrastructure improvements to reduce pedestrian exposure, the potential for pedestrian/vehicle conflicts, and increase pedestrian visibility
 - Perform before/after studies to evaluate and identify the most effective pedestrian safety treatments
 - Research, and where appropriate, implement innovative pedestrian detection at signalized intersections and at other locations along high-risk corridors where driver feedback can be provided via signs and signals



Strategies & Actions for Improving Pedestrian Safety

- Strategy 5: Develop policies and/or guidelines to support pedestrian safety measures
 - Consider revising DelDOT's design policies and guidelines to promote design practices that reduce vehicular speeds and promote pedestrian safety
 - Revise DelDOT's Development Coordination Manual to require additional pedestrian infrastructure improvements related to new developments
 - Evaluate the need for revisions to DelDOT's Complete Streets policy and implementation plan
 - Initiate a Pedestrian Safety Stakeholder group with membership from appropriate state agencies, advocacy groups and the public to identify pedestrian safety and connectivity improvements, policy updates and improved collaboration between state and local agencies, consistent with the objectives of the 2021-2025 SHSP



Strategies & Actions for Improving Pedestrian Safety

- Strategy 6: Improve data collection of pedestrian crashes and monitor trends
 - Working with the Division of Substance Abuse and Mental Health (DSAMH), share data to link mental health issues and substance abuse with traffic and pedestrian travel patterns to improve educations outreach to vulnerable populations
 - Correlate pedestrian crashes with population changes associated with summer resort seasons, holiday shopping and other times that increase pedestrian activity and if necessary, identify appropriate pedestrian safety countermeasures
 - Correlate pedestrian crashes to income levels and homeless populations in Delaware and if necessary, identify appropriate pedestrian safety countermeasures
 - Implement best practices for the use of the new pedestrian origin-destination data to capture improved data about pedestrian travel patterns and crashes
- Strategy 7: Improve emergency services and incident management to address pedestrian safety
 - Evaluate the expansion of DelDOT's Motorist Assistance Patrol (MAP) to increase services along interstates, freeways, and expressways to reduce pedestrian exposure during vehicle breakdowns



2021 Roadway Management Conference

THANK YOU!!!

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View the SHSP Here: deldot.gov/Programs/DSHSP/

Pedestrian specific information can be found at: <https://deldot.gov/Programs/DSHSP/index.shtml?dc=pedestrians>

To Report a Road Condition: <https://deldot.gov/Traffic/ReportRoadCondition/index.shtml>